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Magnetic Resonance	Epidemiological Cancer
Molecular Orbital Calculations	Advanced Plasma Systems
Energy Transfer	Energy Storage

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR Tokyo, with

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19. KEY WORDS (contd.)

Homopolar Generators
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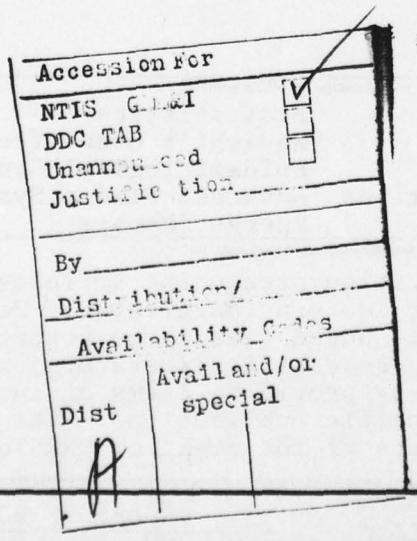
Antarctic Research
Coral Studies
Seaweed Studies
Aquaculture
Oceanographic Research
National Oceanographic Bureau
Research Vessels
Survey Vessels
Earthquake Statistics
Seismology
Japanese Mathematics
Stochastic Point Process
Computer-Aided Design
Shipbuilding
GARP (Global Atmospheric Research Program)
Japanese University Computers
Natta-Ziegler Catalysis
Isomers
Polymer Conductors
Electrical Conductivity
Polyacetylene
Hygrometry
Equation of State
Tribophysics
Catalysis
Zeolites
Field Ion Microscopy
Polymers
Chemical Kinetics
Metrology
Metals
Plasticity
Deformation of Metals
Dislocations
Yield Points
Fracture
Statistics
Probability
Stochastic Processes

20. ABSTRACT (contd.)

certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.



CONTRIBUTORS

Mitchel Weissbluth, currently on the staff of ONR Tokyo, is Professor of Applied Physics, Stanford University. His research activities included the development of liquid propellant rockets, meson production, linear accelerators for medical use, biological effects of high energy radiation, electron spin resonance in biological molecules, Mossbauer resonance in heme proteins, effects of high magnetic fields on enzymes, theoretical aspects of the action of hemoglobin, acoustic and X-ray absorption in biological material. Weissbluth served with ONR London in 1967-68 and worked at the Weizmann Institute in Israel in 1960-61 under a Fulbright grant. He is a past president of the International Society of Quantum Biology.

William J. Blot is Head of the Analytical Studies Section of the National Cancer Institute's Environmental Epidemiology Branch. His research focuses on identifying and evaluating the causes of cancer in man. In connection with his professional activities in statistics and epidemiology, Dr. Blot resided in Japan from August 1970 until June 1972. His current research focuses on identifying and evaluating the causes of cancer in man. He recently returned to Japan on a short visit, during which he led a delegation of American biostatisticians and epidemiologists to Japan to help promote the development of these disciplines and their application to cancer research.

Ihor M. Vitkovitsky completed his higher education in the United States although he was born in Lviv, Ukraine. He is currently Head of the Pulsed Power Section of the Plasma Physics Division at the Naval Research Laboratory. Recent accomplishments include the development of explosively driven opening switch (for application in inductive storage and electrical power transmission systems) and new methods for propagation of guided discharges in the atmosphere.

Francis A. Richards, presently on the staff of ONR Tokyo, is Professor of Oceanography and Associate Chairman for Research, Department of Oceanography, University of Washington, Seattle. His research interests in chemical oceanography include analysis of sea water, plankton pigments, oxygen deficient and sulfide-bearing environments in the ocean and interrelationships among the branches of oceanography through chemistry. Since 1973 Richards has been Editor of *Deep-Sea Research*. At the invitation of the host governments, he has conducted research at the Instituto Oceanografico, Universidad de Oriente, Cumana, Venezuela, during the summer of 1960 and at the Turkish Naval Office of Hydrography and Navigation in the fall of 1964. Under the sponsorship of the United States-Japan Cooperative Research Program of the National Science Foundation, Richards spent six months in 1970 at the Meteorology Research Institute, Tokyo, and an additional six months at the Research Institute for Food Science, Kyoto University.

David Vere-Jones (Ph.D., Oxford) is a Professor in the Mathematics Department of Victoria University in Wellington, New Zealand, a Fellow of the Royal Statistical Society and a Member of the International Statistical Institute. His interests, which include stochastic processes and point processes, have focused extensively on the application of such processes to earthquake analysis and prediction problems. These earthquake-directed interests have carried him to many countries including Japan and the United States. The present article was written while he was a visiting Professor at the Institute of Statistical Mathematics, Tokyo, on an award from the Japan Society for the Promotion of Science.

Richard F. Riesenfeld is an Associate Professor in the Computer Science Department at the University of Utah. He is currently on sabbatical leave at Carnegie-Mellon University in Pittsburgh. Riesenfeld has written extensively and lectured frequently on the subject of computer-aided geometric design, his area of specialty.

Anita P. Skelton is associated with the Mitre Corporation, Mclean, Virginia, as a systems engineer. She was formerly a mathematician/programmer in the Research ComputationCenter, Naval Research Laboratory, where she

was its representative to the Navy Laboratory Computer Network. Her interests extend to many areas of the computer field such as computer languages, computers, communication devices, networking protocals, computing media, etc. She is a member of the Association of Computing Machinery.

Elliot A. Kearsley, recently on the staff of ONR Tokyo, has returned to the Polymers Division of the National Bureau of Standards, Gaithersburg, Maryland. His personal researches are centered on the rheology and mechanical properties of materials. He and his colleagues at NBS have developed a model of non-linear viscoelasticity which is widely used to describe the complex behavior of liquids and solids.

E. H. Lee is Professor of Applied Mechanics in the Department of Mechanical Engineering and also Professor of Aeronautical Engineering in the Department of Aeronautics and Astronautics at Stanford University. His main interests are in the applied mechanics of non-elastic media, especially plasticity and viscoelasticity. Other interests include non-linear continuum mechanics at finite strain involving dynamic problems such as shock wave propagation in metals. Lee is currently working on the analysis of metal-forming processes. In 1976 Lee was awarded the Timoshenko Medal of the American Society of Mechanical Engineers and during 1975-76 he was a Fellow of the John Simon Guggenheim Memorial. Lee is a member of the National Academy of Engineering. In 1969 he was elected a Fellow of the Institution of Mechanical Engineers, London.

Bruce J. McDonald was associated with the Mathematical and Information Sciences Division of ONR Headquarters for ten years prior to his current assignment as Scientific Director of ONR Tokyo. His academic background is in the physical and mathematical sciences and his interests extend to many other areas in engineering and technology. He has resided in Japan since November 1977.

COVER: Designed by Eunice Mohri, with Kanji characters "Tō" and "kyō" drawn by Seikoh Sakiyama, both of ONR-Tokyo.

CONTENTS

SOME BIOPHYSICAL RESEARCH IN JAPAN

Mitchel Weissbluth

Late summer of 1978 was hot and humid and the currency exchange rate was distinctly unfavorable for most foreigners. Nevertheless, during the first week of September, approximately 1,000 scientists from outside Japan joined about an equal number of Japanese scientists for the Sixth International Biophysics Congress in Kyoto. Moreover, immediately before and after the Congress there were 15 other related meetings distributed among the cities of Kyoto, Nara, Kobe and Hakone. This was indeed a rare opportunity to observe, in an international setting, the broad range of activities encompassed under the general heading of biophysics.

It was clearly impossible for any single individual to attend, much less absorb, more than a small fraction of the offerings. In what follows I shall attempt to give my impressions and to summarize some aspects of four meetings with special emphasis on Japanese contributions: (1) The International Conference on the Application of the Mossbauer Effect, Kyoto, August 28 to September 1, (2) The Sixth International Biophysics Congress, Kyoto, September 3-9, (3) The Symposium on Quantum Biophysics, Kyoto, September 9-10, and (4) The Eighth International Conference on Magnetic Resonance in Biological Systems, Nara, September 11-14. The first two were held at the Kyoto International Conference Hall (KICH), a most elaborate and elegant convention center designed in a bold and imaginative architectural style and situated on a lake with a backdrop of rolling hills. The third meeting, with a relatively small number of participants, took place in Kyoto University's Yukawa Hall, so named in honor of H. Yukawa who was awarded the Nobel prize in physics in 1949 for his contributions to the theory of nuclear forces. The fourth meeting took place in the ancient capital city of Nara noted for its lovely parks, magnificent temples and domesticated deer which roam freely in many parts of the city.

It has been two decades since Rudolf Mossabuer discovered that under proper conditions gamma rays from certain radioactive species are emitted with energies essentially undiminished by recoil effects and therefore have an extremely narrow line width. Spectroscopic applications of such radiation have proliferated into numerous fields. The Kyoto Conference on the Application of the Mossbauer effect, organized by a committee under the chairmanship of K. Ono of the Institute of Solid State Physics, Tokyo University, was subdivided into 14 sessions each devoted to a particular area of application as, for example, surface phenomena and catalysis, amorphous materials, magnetic hyperfine interactions, magnetic materials, metals and alloys, lattice dynamics, chemical structures, earth science and archeology, and biological systems. In the last mentioned session, Y. Maeda of the Research Reactor Institute, Kyoto University, Osaka, reviewed the Mossbauer studies on the iron-ligand binding in hemoproteins and related compounds. Since hemoproteins contain iron as active centers and since ^{57}Fe as a decay product from ^{57}Co is a very convenient Mossbauer nuclide, hemoproteins either containing a natural abundance of ^{57}Fe (in the ground state) or isotopically enriched are suitable subjects for Mossbauer investigations. A note-worthy recent accomplishment of Maeda's group has been the determination of the electric field gradient tensor in a single crystal of myoglobin.

The President of the Organizing Committee of the Sixth International Biophysics Congress was M. Kotani who, for many years, has been a dominant figure in Japanese biophysics and is also well-known internationally. Kotani is currently the President of the Science University of Tokyo. As a leading theorist in molecular physics he has made basic contributions to the electronic structure of hemoproteins dating back to the early 1960s. Much of Japan's strength in that field can be attributed to his influence. At the opening ceremonies, Kotani and B. Chance (United States), President of the International Union of Pure and Applied Biophysics under whose sponsorship the conference was held, addressed the participants in the sumptuous Main Hall of KICH. Chance's talk focussed on the numerous contributions physics had made to biology. Practically every experimental tool known to physicists has been applied to biology. The list is long and impressive and one might hope that in the not-too-distant future, physics will not only contribute methodology but will also help to elucidate fundamental biological processes. An

indication that this might already be happening is provided by the suggestion of quantum mechanical tunneling in biological electron transport. Kotani recalled two major events that occurred during his active scientific career. One was the London-Heitler theory of molecular bonding which came into existence around 1930 and provided the physical basis for understanding the stability of molecules. The second event occurred some 30 years later when the structures of DNA, myoglobin and hemoglobin were revealed by X-ray diffraction methods through the work of Watson, Crick, Wilkins, Kendrew and Perutz. This laid the foundation for molecular biology which is the discipline concerned with the understanding of biological phenomena on the basis of molecular structure and dynamics. Thus, the three basic disciplines - physics, chemistry and biology - have been conceptually interconnected and it is in this general context that Kotani views the field of biophysics. The next five days were filled with simultaneous symposia, poster sessions, discussions devoted to specialized topics, etc., and on the evening of the fifth day, in a blaze of spectacular fireworks, the Congress ended.

Among the physically oriented papers, two might be singled out. S. Yomosa, Department of Physics, Nagoya University, derived an explicit expression for the temperature dependence of the excitation energy transfer rate (Förster formulation) in terms of the resonance transfer accompanied by phonon emission and absorption. The theory was applied to an analysis of the picosecond fluorescence data for the photosynthetic pigment system to provide an estimate of the mean excitation transfer distance between light-harvesting pigments and between reaction center chlorophyl molecules. K. Imai, Medical School, Osaka University, obtained oxygen equilibrium curves of human adult hemoglobin under a variety of conditions of temperature and pH with and without organic phosphates. The equilibrium curves were fitted to a 4-step Adair model each characterized by a single constant. It was found that in the first three steps there is a near cancellation of the entropy and enthalpy components of the free energy. The fourth step does not have this characteristic.

On the weekend following the Biophysics Congress, the Symposium on Quantum Biophysics, organized by S. Yomosa, Nagoya University, and C. Nagata, National Cancer Center Research Institute, Tokyo, was held in Kyoto University. In practice, quantum biophysics has most often been synonymous with molecular orbital computations on biological molecules or portions thereof which behave as active centers. In some cases, environmental effects, e.g., the solvent, are also taken into account. Although molecule orbital theory is quite straightforward, computational compromises are always necessary and have led to a variety of formulations which differ from one another in the nature of the approximations. As computer technology has advanced the calculations have become more ambitious but it is nevertheless useful to keep in mind that the precision of a molecular orbital calculation is essentially inversely proportional to the size of the molecule.

Some of the papers by Japanese scientists are the following: H. Kashiwagi, Institute of Molecular Science, Okazaki, and K. Ohno, Hokkaido University, performed *ab initio* calculation on Co-porphine and Cu-porphine. From the energy levels of neutral and ionized species and their charge distribution they were able to compute excitation energies and to study the character of the ligand bonds. Y. Seno, Nagoya University, and I. Otsuka, Science University, Tokyo, investigated the iron-porphyrin-imidazole system by means of semi-empirical SCF-ASMO-CI calculations. They succeeded in reproducing the main features of the low-lying $3d^6$ states estimated by ligand field theory. These calculations were subsequently used as a basis for the explanation of MCD spectra in deoxymyoglobin. K. Morokuma, Institute of Molecular Science, Okazaki, reported on studies of photoisomerization of polyenes based on *ab initio* and semi-empircal MO calculations of potential surfaces, molecular geometries, transition state normal modes and the reaction paths. A. Imamura, Shiga University of Medical Science, computed the electronic structures of several polyamino acids by the tight binding approximation using the CNDO/2 method. He concluded that poly-L-alanine in the right-handed α helix configuration is more stable than as a left-handed helix whereas poly-L-proline is equally stable in the two forms. S. Yomosa, Nagoya University, studied self-trapping states of dimeric molecules and their radicals such as intermolecular charge transfer states or the bound states of solvated electrons. He attacked such problems by solving the nonlinear wave equation derived from a variational equation which states that the free energy of the total system consisting of the solute and solvent is a minimum for an arbitrary variation of the electronic structure. Y. J. I'Haya and H. Ito, Denki-Tsushin University, used a Green function method to develop a formulation of the UV, ORD, and CD bandshape functions of a polymer composed of N identical monomers.

BIOPHYSICAL RESEARCH IN JAPAN – M. WEISSBLUTH

Nuclear magnetic resonance (NMR), the phenomenon based on electromagnetic transitions among the magnetic substates of nuclei was discovered independently in 1946 by two groups, one under the direction of F. Bloch at Stanford and the other under E. M. Purcell at Harvard. In the intervening three decades NMR and its close relative ESR (electron spin resonance) have become indispensable tools in chemistry and biology. The Eighth International Conference on Magnetic Resonance in Biological Systems was organized by a committee with S. Fujiwara, University of Tokyo, as Chairman. A highlight of the meeting was the presence of F. Bloch who recalled some of the early history which led to the development of NMR. As Bloch related it, his objectives had nothing to do with chemistry and/or biology. At that time he was interested in measuring the magnetic moment of the neutron and he simply needed an improved method for measuring magnetic fields. This is but another case, among many, in which one scientific field reaps considerable benefit from totally unrelated developments in another field.

Japanese developments are evident in practically all aspects of magnetic resonance research. S. Ohnishi, Kyoto University, used spin labels to study the dynamical membrane phenomena when viral particles are attached to erythrocytes. In this fashion he obtained results on the intermixing of phospholipids between the viral envelope and the cell membrane. I. Morishima (Kyoto University) used ^{15}N NMR in investigation of hemoproteins and their model compounds. Y. Arata (Tokyo University) conducted studies of Bence – Jones proteins with proton NMR and M. Kainosho, Ajinomoto Co., observed ^{13}C NMR spectra of various metabolites in intact plant tissues.

It is quite evident from these meetings that Japanese scientists, together with American and European colleagues, are actively engaged in the pursuit of a fundamental understanding of biological processes using all available physical tools, experimental and theoretical.

UNITED STATES-JAPAN CONFERENCE ON BIOSTATISTICS IN THE STUDY OF HUMAN CANCER

William J. Blot

This past May the Japan Society for the Promotion of Science (JSPS) and the United States Japan-Cooperative Cancer Research Program jointly sponsored a conference which brought together American biostatisticians with Japanese mathematicians and epidemiologists for a four-day meeting in Hiroshima. The objectives of the conference were several, foremost being an exchange of ideas in statistical methods and approaches applied in cancer research in the United States and Japan. Interestingly, the conference provided a formal introduction, perhaps for the first time, between the mathematical statistics and the medical (cancer) research communities in Japan, with the American contingent, in effect, serving as a go-between.

The field of statistics as an independent discipline has not developed in Japan as it has in the United States. In the U.S. there are over 190 universities offering graduate degrees in statistics, about 35 of which specialize in the field of biostatistics. In contrast there are no independent departments of statistics in any Japanese university, although mathematical statistics is taught under the mathematics curriculum in several of Japan's national and private universities. One of the reasons for the Hiroshima conference was in fact to foster the development of biostatistics within Japan, in order that some of the tremendous pool of latent mathematical talent in the country might be directed toward more applied research, particularly in the field of cancer and biomedical science. The potential for creative statistical research in Japan had been recognized by many, but in particular by a physician in the U.S. National Cancer Institute, Dr. Robert W. Miller, who heads the Analytical Epidemiologic Committee of the United States-Japan Cooperative Cancer Research Program. Primarily through his efforts, funds were made available for a group of eight Americans to visit Japan. With the assistance of Dr. Miller's counterpart in Japan, Takeshi Hirayama, M.D., Chief of Epidemiology at the National Cancer Center Research Institute in Tokyo, the JSPS similarly provided funds for about 25 Japanese scientists to attend, and the Hiroshima conference was scheduled.

The conference was held at the Radiation Effects Research Foundation (RERF) in Hiroshima. RERF is one of the few institutions in Japan with a permanent biostatistics staff actively involved in medical research, in this case the evaluation of long-term effects of atomic radiation upon human populations. RERF members participated in the sessions, but the great majority of conferees were from other institutions in Japan, including the Institute of Statistical Mathematics, The National Cancer Center Research Institute, and Mathematics and Public Health Departments at Tokyo, Osaka, Kyushu and other universities. The agenda for the conference, which is shown on the following page, was jointly organized by Professor Akio Kudo (Department of Mathematics, Kyushu University) and myself.

Proceedings of the conference will be published next year in the journal *Environmental Health Perspectives*. In brief, the meeting was divided into four main sections. The first provided an overview of cancer research in the United States and Japan, with the speakers noting how statistical methods have aided this research, as well as pointing out possible areas where further development is needed. The second section, the major one in the conference, dealt with issues in statistics. These included a review of the system of multivariate techniques known in Japan as Hayashi's quantification methods, and papers from the American side on current biostatistical techniques for epidemiologic studies, especially on relative risk and survival function estimation and testing, and general methods for categorical data analyses. A third section of the conference covered data resources available for biostatistical and epidemiological cancer research in both countries. The meeting was concluded by a general discussion of the advantages of collaborative research in medical science.

The conference was successful in its goal of bringing together American and Japanese scientists and fostering a frank exchange of ideas. All the sessions were held in English, but this was not a serious detriment because of the

high competence in English of the Japanese participants and because copies of each speaker's paper were distributed prior to the meeting. The proceedings, highlighted by the review of statistical approaches in medical research, should provide a valuable synthesis for cancer researchers in both countries.

Although it will not be known for several years whether the conference will result in an increase in biostatistical activity in Japan, initial indications are that its impact may be substantial. The structural organization of Japanese universities, and other institutions in Japan as well, is predominantly vertical in nature, so that interaction between different departments is minimal. The gathering of medical scientists and mathematical scientists at the Hiroshima conference may help to loosen some traditional barriers to collaborative research, and, in fact, is being considered by The Japan Society for the Promotion of Science as a possible model for future conferences in the country.

U.S.-JAPAN CONFERENCE ON BIOSTATISTICS IN THE STUDY OF HUMAN CANCER

HIROSHIMA, JAPAN

May 22-25, 1978

I. Introduction

1. Objectives of the Conference. Akio Kudo, Kyushu University

2. Cancer Biostatistics in the U.S. and Japan. William Blot, National Cancer Institute

II. Overview of Cancer Research Pertinent to Statistics in the U.S. and Japan

1. Cancer Epidemiology in Japan. Takeshi Hirayama, National Cancer Center Research Institute

2. Statistics in Biomedical Research. Robert Miller, National Cancer Institute

3. Animal Experimentation and Its Relevance to Man. David Hoel, National Institute of Environmental Health Sciences

4. Cancer Treatment–Finding Cures. Edmund Gehan, University of Texas

III. Biostatistical Methods in Cancer Epidemiology

1. Review of the Methods of Quantification. Yutaka Tanaka, Institute of Statistical Mathematics

2. Recent Application of Quantification II in Japan Medical Research. Ryuichiro Suzuki, Center for Adult Disease

3. Designing Case-control Studies. Takashi Yanagawa, Kyushu University

4. Statistical Analyses of the Relative Risk. John Gart, National Cancer Institute

5. Some Applications of Categorical Data Analysis to Epidemiological Studies. James Grizzle and Gary Koch, University of North Carolina

6. Statistical Methods for Censored Survival Data. Normal Breslow, University of Washington

7. Statistical Methods for Evaluation of Influencing Factors on the Prognosis of Gastric Cancer. Masasi Goto, Yoshihiro Matsubara, Hiroaki Nakazato, and Choichiro Asano, Shinogi Kaiseki Center, Aichi Cancer Center, and Kyushu University

8. Clinical Trials in Cancer Research. Edmund Gehan, University of Texas

IV. Study Environments in the U.S. and Japan

1. Data Resources for the Study of Cancer in Man

a. Population Registries and Other Record Resources for Epidemiologic Cancer Research. Tomio Hirohata, Kurume University

b. Developing Clues to Environmental Cancer: A Stepwise Approach Using Cancer Mortality Data. William Blot, Joseph Fraumeni, Thomas Mason, and Robert Hoover

c. National Cancer Mortality and Incidence in Japan. Minoru Kurihara, Research Institute for Nuclear Medicine

d. Study of Cancer Mortality by the Grid Square Method. Toshiteru Okubo, Jichi Medical School

e. Radiation Effects Research Foundation: A Japanese-American Scientific Endeavor-Data Resources for Cancer Studies on a Cohort of A-bomb Survivors. Hiroo Kato, Radiation Effects Research Foundation

2. Computer Facilities and Packages for Biostatisticians

a. Statistical Computing in the U.S. Roy Milton, National Institutes of Health

b. The Statistical Principle and Methodology in the NISAN System. Choichiro Asano, Kyushu University

c. A Method of Record Linkage. Akira Oshima, Fumio Sakagami, Aya Hanai, and Isaburo Fukimoto, Center for Adult Disease

3. Role of Mathematical Brains in Cancer Research: Panel Discussion

V. Open Discussion and Summary

Table 1: Homopolar Generator Programs

Organization:	Texas University	Westinghouse	Australia Universities
Key Staff Attending:	H.G. Rylander W.F. Weldon P. Wildi	C.J. Mole I.R. McNab C.R.A. Marshall	E.K. Inall J.W. Blamey P.O. Carden J.J. Lowke R.A. Marshall A.D. Stokes S. Kaneff
Capabilities:	• HPG design team • Fabrication • Testing • Fast Discharge HPG Studies	• HGP design team • Brush development • HPG Construction • Fast Discharge HPG • Superconducting coils	• Major HPG facility (1MA, 200 MJ) • Design/Test team • Arc Research and testing • Unique Research Facility available on short notice • Coil design

Table 2: Addresses of Persons Named in Table I

Dr. E. K. Inall Mr. J. W. Blamey Dr. P. O. Carden Prof. S. Kaneff Mr. R. A. Marshall	Department of Engineering Physics Research School of Physical Sciences Australian National University Canberra, A.C.T. 2600
Dr. J. J. Lowke Dr. A. D. Stokes	Electrical Engineering Department University of Sydney Sydney, N.S.W. 2006
Mr. C. J. Mole Dr. I. R. McNab Mr. R. A. Marshall (on leave from ANU in 1978)	Westinghouse Electric Corporation Research and Development Center Pittsburgh, Pennsylvania 15235
Prof. H. G. Rylander Dr. W. Weldon	Department of Mechanical Engineering University of Texas Austin, Texas 78712
Dr. P. Wildi	Fusion Research Centre University of Texas Austin, Texas 78712

The above tables do not include application programs involving opening and closing switches discussed also at the Seminar. These switches as well as components such as inductors are a necessary interface between the HPG current source and the experiment. In reference to the concerns of the community working on the magnetic confinement of plasma for fusion, one of the problems that was studied was that of whether HPG machinery can become a cheaper

source of current compared to the alternators (with rectifiers). Generally, it was obvious that further operational experience with HPG's is needed, if they are to compete effectively with alternators. The need for additional experience is similarly true in considering HPG's as a cheap source of energy for large high power pulsers, where the interfacing with the high voltage must be dealt with.

A large number of papers were presented by the Australian participants at the Seminar. This is not surprising since Canberra University has a fascinating HPG facility. Not only is it characterized by the largest available energy at current rating of up to 1.5 MA (which can be increased to 3 MA by expanding the HPG-to-load bus-bar rails); its power is distributed to a number of experimental areas (all quite large in size). The facility is capable of pulsing rates of about three per hour with future plans for even faster pulsing required by the TL 4 Tokomak experiment, being completed at Canberra. The facility provides comfortably about 200 MJ. In experiments just completed, 300 kC magnet was powered by the HPG. In another experiment, on electromagnetic acceleration of few grams of mass to high velocity (5-10 km/sec), current output is crowbarred to protect the HPG from high voltage pulses. This experiment uses a 2 MJ inductive storage coil (operating at 500 kA).

Another highlight of the Seminar was the range of the design efforts discussed by participants for developing the HPG's for driving magnetic field coils of plasma-confining devices. The perennial pulsed power community funding problems do not permit at this time any extensive construction so that the present HPG's with storage capacity of few megajoules can be extended to 100 MJ range. Designs for such units, however, have been completed. Some are based on use of superconducting magnets (Westinghouse) and are planned as "high voltage" sources using four series rotors (Texas University) and multi-rotor (Argonne, Westinghouse) units. None of the approaches have considered self-excitation which has been incorporated in the NRL HPG unit, since compactness and external power is not a major concern in this phase of fusion power source development.

Brush design remains a problem as far as operational maintenance and HPG optimization is concerned as well as for continuous running HPG's. It does not appear to represent any difficulty in building relatively compact units. Solid brushes at up to 250 m/s rim speed can now take 1-2 kA/cm^2.

The state of development of homopolar generators can be summarized by indications in Seminar presentations and in subsequent discussions that the time scales for developing of HPG systems and associated inductors (and/or transformers) with energy in 100's of megajoules are a minimum of one year design effort and not less than two to three years for construction and testing. For example, 50 MJ Texas University HPG was stated to require about two years for construction. Development of more HPG's with demanding performance parameters, such as, for example, millisecond output, will require substantially longer effort. Joint programs, especially those which may require rapid development, if they were to include United States and Australian expertise, would shorten the design effort. Appropriate agreements between Australian and U.S. Governments are in existence, indicating that no formidable barriers for such cooperation exist.

ADVANCED PLASMA EXPERIMENTS (JAPAN)

The visit to the Institute of Plasma Physics (IPP) at Nagoya University provided a good example of the need for pulsed power sources in plasma physics research. Because of the nature of the experimental programs of the Institute, a variety of power systems is being utilized, ranging from inertial energy storage to very high power ($\sim 10^{12}$ W) pulse line generators. This comes about because of the needs of the Institute of Plasma Physics, which is administratively part of the University of Nagoya, but acts completely independently in the choice of its programs. Its programs, conducted by about 150 people, are funded by the Ministry of Education, having as its purpose germination of seed experiments which in later phases are undertaken by other research groups in Japan. The Institute is keenly aware of pulse power needs and the influence that its development will have on future programs.

The IPP experimental programs center around the study of containment of plasma that are of interest to fusion programs in Japan. Large experiments are mounted relatively easily due to the existence of 100 MW flywheel storing 600 MJ in rotational energy. Its run-up time is eight minutes. This system, designed by Dr. Miyahara, provides power to several experiments.

ADVANCED PLASMA SYSTEMS – I. M. VITKOVITSKY

The more outstanding experimental programs at the Institute are those at the frontier of plasma research. They involve substantial development of pulse power technology. Some features of the programs are listed:

High Beta Tokomak (JIPP II). This experiment, one of the major fusion experiments in the world, has operated sufficiently long to establish preliminary plasma parameters (T_e = 1.5 keV, T_i = 0.7 keV, 10 msec confinement).

RCF Spindle Cusp Experiment. This is the major plasma confinement experiment at IPP designed to study plasma leakage from magnetic cusps. The cusp confinement experiment construction has now been completed. 1MW rf plugs (circular plates applying voltages up to 5 kV/cm) will be used to minimize losses. Tests with 2 kV/cm fields indicate that 2 x 10^{12} cm^{-3} density plasma (produced by an injection gun) has its loss rate decreased by a factor of about 10, as compared to tests with deactivated plugs. The second and third phases of the program will include the use of DT ice for plasma filing and injection of neutrals for heating.

Laser II Experiment. This experiment was set up for reproducible injection of the D_2 ice pellet into the RCF experiment. In this experiment a feedback system has been built to control the spatial position of the focus of the laser beam used for heating of the ice pellet. Plasma produced in this experiment (using 100 J glass laser) is highly reproducible.

STUDIES OF INERTIAL CONFINEMENT TECHNIQUES (JAPAN)

In addition to the magnetic confinement programs, IPP also conducts programs related to inertial confinement. These range from studies of laser target interactions to development of very high power pulse generators with specialized properties. Some aspects of magnetic and inertial confinement programs are common to both, as, for example, in the case of the large electron beam pulser (PHOEBUS II) recently purchased from Physics International, Inc. The major experiments are:

PHOEBUS II. This is an experiment studying the injection and confinement of an electron beam for heating of toroidal plasmas. Presently PHOEBUS II consists of a 70 cm diameter torus with electrons tangentially injected into the torus, generated by a small water dielectric pulse line driven by 20 kJ Marx. 10% of the beam electron density of 10^{11} cm^{-3} is confined for a long time (0.5 msec) in a plasma of 10^{12} cm^{-3}. This experiment is being upgraded by purchasing 75 kJ Marx and variable impedance (1 to 5 Ohm) water pulse line to provide 50 kJ (1.8 MeV) beam for injection. This generator was scheduled for installation early in 1978.

Focussing of Ion Beams for Pellet Fusion. An interesting method for focussing multiple ion beam sources or large area ion sources has been proposed by Dr. A. Mohri. This method, using toroidal magnetic field lens to focus ions on small fusion pellets, appears to provide an elegant alternative method for the purely ballistic mathods being developed.

The overall impression of the policy pursued at IPP is that it strives to maintain complementary efforts run in parallel in order to move rapidly in a chosen direction. Substantial amount of small-scale experimentation is done following a type of basic research philosophy. The experiments exhibit great sophistication (i.e., DT pellet feedback, cusp plugging). The Institute policy appears to favor future involvement in the basics of very high power technology–without doing the large-scale development in the IPP laboratories.

TWELFTH INTERNATIONAL SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT

Francis A. Richards

A beautiful new cultural center, convention hall, and hotel complex has been built on land reclaimed from Manila Bay during the administration of First Lady and Governor of Metro Manila, Imelda Romualdez Marcos. This was the site of the Twelfth International Symposium on Remote Sensing of Environment, 20-26 April, 1978. The location was significant because it emphasized the fact that the Philippine Republic is a developing nation and as such had been chosen as the host nation for the first of these symposia to be held outside the United States. During the closing ceremonies unanimous satisfaction with both the location and the content of the symposium was evident. My impressions were the same: the facilities were good, the program rich and varied, sessions were well attended, and Philippine hospitality is indeed gracious and warm.

During the five days of sessions there were nearly 60 oral presentations of papers at five plenary and four pairs of concurrent sessions. In addition, an important feature of the meeting was seven poster sessions at which some 170 presentations were made. The advantages of poster sessions are numerous, and these sessions were well organized, with each author being scheduled for a four-minute oral presentation during the 2½ hours his poster was on display. All contributed papers were given in poster sessions; only invited papers were presented as formal talks.

There were exhibits by some 15 commercial organizations from the United States, Canada, England, France, and East Germany, of various remote sensing equipment, products, and services. The exhibits were interesting and attractive and the exhibitors provided a sumptuous buffet and bar in connection with the opening of the exhibits and coffee throughout the meetings. There were also exhibits by several government agencies demonstrating various techniques and uses of remote sensing. These included National Oceanic Atmospheric Administration, U.S. Agency for International Development (AID), the U.S. Department of Agriculture, U.S. Coast Guard, the U.S. Geological Survey, National Aeronautics and Space Administration, the Philippine Coast and Geodetic Survey, and the Philippine National Resources Management Center (NRMC). ONR was represented by the membership of Mr. F. P. Diemer on the Executive Committee. The symposium was organized and conducted by the Environmental Research Institute of Michigan and the Natural Resources Management Center of the Philippines. Dr. Jerald J. Cook of the former institution and Dr. Celso R. Roque of the latter were co-chairmen.

The importance of remote sensing and of the symposium to the Philippines and other developing countries was stressed in the keynote address by President Marcos and by the fact that the President himself gave the speech. It should be noted that the speech was delayed for over an hour because of the late arrival of some 90 delegates caused by a flight delay.

President Marcos emphasized that scientific exploration and discovery by remote sensing was just beginning to unfold and that an imbalance was created when such technology was in the hands of a few nations. With the advent of Sputnik, the earth could be viewed from a new vantage point. The new view reveals a world without borders; it suggests the fragility of the system that maintains life on earth, and it emphasizes the limitation of earth's natural resources. He pointed out that the third world stands to benefit most from remote sensing because natural resources are of primary importance to developing countries; these are best assessed and their development best planned with the aid of remote sensing. Topics of particular importance are such things as changing forest patterns, the erosion of the soil, the pollution of waterways, and changes in natural resources in general.

It was natural for President Marcos to consider political questions raised by the advent of satellite sensors—questions of particular interest to the third world. These concerned what he called "commonly owned" resources, such as marine areas, and whether or not orbiting satellites should be governed by an international body in the

interest of resources and of national privacy. An international forum to consider national sovereignty was suggested. Perhaps the most concrete suggestion he made, and the one on which he is most likely to act on effectively, was for the joint establishment of a remote sensing center by the ASEAN nations - Indonesia, Malaysia, Thailand, Singapore, and the Philippines.

REMOTE SENSING ACTIVITIES IN THE PHILIPPINES

The history and growth of the remote sensing program of the Philippines was described more fully by Dr. Celso R. Roque of the Natural Resources Management Center of the Department of Natural Resources. Aerial surveys to assess land use patterns and natural resources were begun immediately after World War II and were carried out by several governmental bureaus and commercial surveying companies. Mechanisms for better using remotely sensed environmental data were strengthened by the establishment of the Natural Resources Management Center in October, 1977, and during the Philippine Remote Sensing Workshop held in December, 1977. The workshop defined the major remote sensing programs and projects of the country using aircraft photography, multispectral photography, Landsat imagery, and infrared photography. The programs concerning applications to Natural Resources and Environmental Surveys encompass (a) land use/agriculture, (b) forestry, (c) geology/meteorology/hydrology, and (d) coastal and aquatic resources/oceanography. There are also programs on data processing and applications. It is not surprising for an island nation such as the Philippines to put considerable emphasis on the aquatic environment – both fresh water and marine. Aquatic programs include charting and mapping (bathymetry, updating of navigational charts with emphasis on shoals and reef flats, coral reef mapping, major current patterns, and local currents within bays and inlets), inventories (swamplands, inland water areas, shallow areas for mariculture), and monitoring (shoreline changes, water quality of bays, inlets and lakes, eutrophication levels), and the productivity classification of lakes. Among the geology and meteorology programs are the monitoring of siltation due to mine tailings, geological mapping, and recording cloud cover distributions.

Current remote sensing activities in the Philippines were described in eight papers at the poster sessions. One was on forest inventory, three were on geological assessments, three on what might be called the land-water interface, and one on the land use classification of Metro Manila. All applications depended primarily on Landsat imagery, various techniques for displaying and interpreting satellite data, comparison with ground truth observations, and the application of the correlations between ground truth observations and satellite imagery to interpretations of unknown regions or of changes where repeated imagery is available. All the work reported made use of the General Electric Image 100 multispectral image analyzer, acquired by the Natural Resources Management Center (NRMC) in 1977. All but one of the papers were primarily the work of NRMC.

One of the geological papers "Processing and Analysis of Landsat Data Covering the Baguio Mineral District," from NRMC, commented on the glaring disparity between the geologic data extracted from Landsat imageries and the data in available geologic maps. The paper suggested that the disparity may arise from the different level of detail available to produce the two maps. The present (conventional) geologic maps are based on detailed on-the-ground studies while the Landsat gives a synoptic overview that shows major and minor regional lineaments not recognized in the lower-level, more detailed studies. It is evident that the two methods of geologic mapping are complementary; the Landsat data are useful in updating the geologic maps by revealing new faults and lineaments and by the realignment of trends of previously defined structural elements, such as fault traces and fold axes. On the other hand, the equipment and material available to the investigators did not permit them to delineate lithological units and their boundaries.

In a study of the structural and lithologic interpretation of northwestern Cebu Island, a combined approach used Landsat and aerial photography (low and medium altitude). Landsat multispectral imagery taken under various solar elevation angles was interpreted using conventional photogeologic techniques and computer-assisted interactive enhancement and signature classification via the G. E. IMAGE 100 system. A not surprising finding was that in all cases, spectral tonal variations in Landsat imagery of heavily vegetated regions require detailed ground truth to determine if the variations reflect botanical, geologic, or other factors. It was also concluded that the combined approach is excellent for geologic analyses in remote regions.

The geologic interpretation of Landsat-1 imagery of Mindoro Island permitted the identification of broad lithologic units, fracture lineaments, and volcanic cones. Texture, pattern elements, and photo tone were used to delineate lithologies in accordance with the degree of induration. As with the Baguio Mineral District, some of the lineaments seen in the imagery correspond to known major faults, but others do not; they are not seen in the field nor on aerial photographs. Some of the anomalies may be related to deep-seated structures that have not been established, but attempts are being made to correlate them by means of a ground geophysical survey.

The three aquatic papers were concerned with the detection and monitoring of water hyacinth *(Eichornia crassipes)* infestation of the lake called Laguna de Bay, coral reef mapping, and mangrove forest inventories.

The water hyacinth can be a pest plant in tropical waters. Infestations of the plant can present hazards to navigation and foul areas used for fish culture. On one occasion several tons of milkfish, which are commercially cultured in pens along the lake shores, were killed. The control and management of the pest require data on standing stocks, rates of production, distributions in time and space, dispersion patterns, areas of rapid growth, and the extent of damage done.

Two Landsat computer compatible tapes (CCT) from overpasses in December 1972 and April 1976 were available for study in an attempt to develop techniques for acquiring the necessary ecological information. Anomalies in the near-infrared bands 6 and 7 appeared as high reflectance lines with lateral, circular, and undulating striations in various parts of the lake. Later collation of secondary information and aerial photographs confirmed that the anomalies represented water hyacinths massed along the boundaries and within the fish pen areas. The features were studied in more detail by transforming the digital data into video displays of false-color 3-band composite imagery. Using these imageries, the spectral signatures of the water hyacinth masses were obtained in terms of their 4-band gray level values.

The analytical scheme worked out using the Landsat 1 and 2 coverage will be used in real time in conjunction with Landsat C coverage. This should lead to new information on the growth and morphological variations among the water hyacinths by determining the relationship between Band 6 and Band 7 gray level values.

Laguna de Bay is large (91,136 hectares) and its monitoring from the surface or by aerial photography would be slow and costly. Satellite imagery should prove highly cost effective in solving this ecological problem.

Mangrove forests characterize much of the world's tropical and semi-tropical shorelines. In the Philippines they are an important resource for tannin, lumber, fish ponds, and other economic uses. Their identification and evaluation from Landsat imagery is being developed by the Natural Resources Management Center. Thirty Landsat scenes covering the entire Philippines are available from Landsat 1 and 2 passes from October 1972 to April 1976. On the basis of locations of known mangrove forests and the availability of secondary information, such as topographic maps, land classification maps, aerial photography, and pertinent literature, 26 training areas representing mangrove areas on different islands were selected and visited. Subscenes containing these areas were then extracted from the CCT. Image analysis and processing were carried out on the video display of the 3-band false-color composite image of these scenes. Spectral signature histograms were extracted and, after verification, were converted into spectral signature curves to show the differences in land cover types. These could then be used for the analysis and mapping of mangrove areas outside the training areas.

Most of the forests in the training areas were in secondary and reproductive stages of development, typically characterized by young growth of *Rhizophora* (the economically most important red mangrove) interspersed with old growths of *Avicennia*, lesser species, and developed and undeveloped fish ponds.

Generally the spectral curves of mangroves are distinct from those of other land cover types although there may be some ambiguity and overlap with mountain and cloud cover signatures. Variations in Band 6 and 7 gray levels are interpreted as representing various growth and morphological stages and physiographic conditions of the substrate.

Follow-up studies of coral reef mapping using Landsat data were reported by Bina, Carpenter, Sacher, Jara, and Lim from NRMC. Three methods of thematic mapping of coral reefs had been reported at the 10th symposium in this series. Apo Reef (southwest of Mindoro Island), the double reef between Cebu and Bohol islands, and the Santiago Island fringing reefs were chosen for the study, the object of which was to separate depth and bottom-type categories. Analysis was on the color TV monitor display. The results were compared with color coded thematic maps prepared by the previously used techniques. Three different digital processing techniques were tried, and each yielded different thematic patterns, some emphasizing depth contours, others emphasizing structural features. To help interpret the maps, a hydrographic survey of the Apo reef area has been carried out and surveys of the other areas are planned. The results will be correlated to evaluate the effectiveness of each technique for emphasizing physiographic features. A preliminary conclusion is that no single digital method will be able to represent the physiographic features of a reef surface, but a combination of the various patterns could produce a more accurate representation.

REMOTE SENSING PROGRAMS IN OTHER COUNTRIES

The wide variety of subjects presented at the symposium cannot be treated even briefly in this report. No attempt will be made to report on the papers from the United States nor the other countries outside the sphere of concern of ONR-Tokyo, and primary attention will be given to aquatic topics.

The most active participants in remote sensing programs in the area bounded by the longitudes of Asia are Australia and Japan.

AUSTRALIA

In Australia, the Department of Science, CSIRO (Commonwealth Scientific and Industrial Research Organization) operates a NASA satellite station. Also the Remote Sensing Association of Australia has branches in each state, an indication of Australian activity. Remote sensing is used in solving many of the problems facing a large country with a small population whose economy is based principally on agriculture and mining.

Among the applications of remote sensing in Australia are geologic mapping, in which rock types and old mine tailings can be identified. Mine safety and coal extraction problems are assisted by remote sensing (CSIRO Division of Mineral Physics). NOAA satellite information is received in several places and used for weather forecasting and for producing flood forecasting models. Pasture signatures have been identified and Landsat data are used to predict wheat and barley crops. Other remotely sensed data (Landsat, color aircraft photography) are being used in forest fire, land cover, and land mapping-use, highway planning, coastal engineering, coastal zone management, coastal sand dunes mapping, and water resources mapping and management. A special application is the mapping of the coast and of ice and snow-free places in Australian Antarctic territory. Color and infrared photography have been used to assess irrigation projects, water seepage, and flood plains.

Under good conditions, water depths of up to about 20 meters can be estimated to within about 10% from Landsat imagery; such data are being used in bathymetric mapping.

An oceanographic program, conducted by CSIRO Division of Fisheries and Oceanography, involves buoy tracking by the NOAA Nimbus VI satellite. Buoys released southwest of Australia in 1976 sensed sea surface temperature and atmospheric pressure. The r.m.s. position error for the Nimbus VI fixes has been found to be within 5km. Cresswell (G. R. Cresswell, Deep-Sea Research, 24, 1203-1209, 1977) reported the trapping of two such buoys in an anticyclonic eddy off the western Australian coast, one for 30 days, the other for 65 days. One such buoy, at the time of the symposium, was still operating after more than two years, during which time it had drifted over 10,000 km. A multinational program (including Australia) is planned during which 300 buoys will be released between 20 and 60°S. latitude, a program that should contribute significantly to our knowledge of oceanic surface circulation.

BANGALDESH

Landsat data from the years 1972-73 and 1976-77 were used to estimate land accretion along the coast of Bangladesh. Suspended sediment is carried down the rivers to form new land in the Bay of Bengal. After deposition,

the sediment may be resuspended by tidal action and redistributed by tidal currents. Maps for the two time periods were generated by digital computing techniques; they showed both the shoreline location and the suspended sediment load in the water. The two maps were used to produce a change detection map; there was an apparent net gain in land during the period.

In some areas of the ocean, Landsat imagery can be used to produce bathymetric charts in water depths up to about 20m, but the sediment loads along the Bangladesh coast resulted in limited success in bathymetric charting.

NEW ZEALAND

Repetitive Landsat data from Pauatahanui Inlet, New Zealand, (41.4°S, 174.9°E) were used to monitor sediment and siltation in the inlet. It was assumed that the MSS (multi-spectral scanner) 7 band (800-1100nm) does not penetrate water and could be used to fix the shoreline contour on available bathymetric charts. It was found that the MSS 5 band (600-700nm) penetrated to depths of 45-50cm, the MSS 6 band (700-800nm) penetrated 10-15cm, and the suspended sediment in the inlet prevented a determination of the depth of penetration of the MSS 4 (500-600nm) band. Thus, one Landsat scene can provide a coarse contour plot of penetration depths, and repetitive coverage permits the resolution of the difference between suspended sediment distribution and bottom features.

SOUTH AFRICA

An attempt has been made to process Landsat data for oceanic features, such as sediment plumes, oil slicks, pollution from fish factories, kelp beds, and possibly plankton patches and fish shoals. The investigation was made in preparation for the forthcoming Nimbus G Coastal Zone Color Scanner experiment (CZCS), which is designed to provide a much higher signal-to-noise ratio for oceanic features than Landsat imagery does. The low S/N ratios available were combined with a pronounced striping effect, and processing effort was aimed at establishing the striping as a data-dependent effect. In this preliminary report it was concluded that many features in the oceans tend not to have well-defined boundaries and some features are so small and spatially ill-defined as to make it difficult to obtain enough sample points to justify the statistical approach used.

SINGAPORE

A paper by Dr. Chong Yean Joo pointed out the possible environmental effects, especially the pollution of coastal areas, by various developmental activities in other areas. The possible geneses of such pollution could include reclamation of land from the sea, clearing of forests, new industrial complexes, damming of rivers, the construction of transportation facilities, and the establishment of recreational areas. Singapore is on the Straits of Singapore/Malacca, connecting the Pacific and Indian oceans, and is a busy international waterway. Landsat scenes of this area include not only the straits but three countries where development is being carried out intensely. It is important that the development not result in environmental pollution. Baseline data are essential to evaluate possible changes.

Present studies have been limited to long term changes by the high incidence of cloud cover, but Skylab and Landsat imagery shows the large scale current and circulation patterns, and siltation of the sea bottom in the straits can be detected. There was a recent four-nation hydrographic survey of the area which, in conjunction with Landsat imagery, provides a good data base from which to evaluate changes.

Suspended particles introduced by rivers can be used as a natural tracer to predict the fate of possible pollutants that may also be introduced by the rivers. On the other hand, in clear shallow waters where the depths are known, attenuation coefficients and bottom reflection characteristics have been compiled for Bands 4 and 5 for sand, flourishing corals, and dead corals.

Relative density contours of suspended matter have been compiled and statistics on radiance levels are being compiled to identify the nature of pollutants in the water, particularly discharges from palm oil and rubber processing plants.

THAILAND

Littoral mud flats in Thailand are an important site for coastal zone aquaculture. In 1972 one of the crops, the mud clam *Andara granosa*, produced 14,000 tons. Thus a good knowledge of the extent of the flats is necessary for planning and management.

A search of Landsat imagery located an image made two hours 40 minutes after low tide and 13 hours before high tide, so that the scene should show nearly the maximum extent of mud flats. A successful map was produced, but a non-standard color transposition was used to enhance the mud flats better than the standard color conventions. With the new combination (Band 4 yellow, Band 5 orange, Band 7 cyan) the mudflats appear as light blue, mangroves as yellowish green, and sedimentation as bluish white. A ground truth survey was conducted using cars, boats, and helicopters. The study showed an area of some 910km^2 of littoral and 3700km^2 of sublittoral mud flats.

INDONESIA

Indonesia has over 13,000 islands and 61,000km of coastline; Indonesian waters cover almost 7×10^6 km^2. It is not surprising that the country is devoting considerable effort to scientific surveys and research in the marine environment. Remote sensing is being used to complement conventional surveys and research from surface vessels.

Aerial photography with a multispectral camera is being used to map coral reefs and benthic features in Bali, and Landsat imagery is being used to map sediment transport in Jakarta Bay, the Surabaja Strait, and in coastal zone studies in South Sumatra.

At present, the National Space and Aeronautic Institute (LAPAN) is trying to develop an aircraft borne radiometer to detect chlorophyll concentrations in the upper layers of the sea, and it is testing a thermal scanner to monitor several types of pollution introduced to the marine environment.

JAPAN

Japanese authors from 25 different industrial companies, universities, and government laboratories contributed some 17 specialized papers and one general overview paper to the symposium. The list of subjects indicates the wide range of applications and technology being used, developed, or investigated: (1) the Japanese geostationary meteorological satellite, (2) surface radar observations of sea ice, (3) analog/digital image processing system "TIAS" (Tokai Image Analysis System), (4) atmospheric effects in airborne sensor and Landsat MSS data, (5) description and analysis of remotely sensed water quality distribution patterns, (6) the integration of Landsat data and the National land data system, (7) JAFSA (Japan Foundation for Shipbuilding Advancement): an airborne remote sensing project in Japan, (8) positioning thermal IR imagery for monitoring volcano activity, (9) remote sensing in the field of agriculture, (10) infrared remote sensing of geothermal areas by helicopter, (11) data restoration techniques and soil mapping applications using aircraft MSS data, (12) a study of the application of remote sensing to saury fisheries in Japan, (13) Japan's receiving and processing facilities for Landsat data, (14) application of texture analysis and image enhancement techniques for remote sensing, (15) photographic remote sensing at Chiba University (a) studies of Kumano River water and (b) analysis of concrete moisture by simulation, (16) volcanic gas eruption velocity sensor, and (17) land-use map compilation system from aerial MSS data.

A paper by M. Sekioka and K. Yuhara described a technique for determining the temperature distribution in geothermal areas using a helicopter-borne infrared thermocamera giving thermal images on television tape. The spectral band of the camera is 9 to 14 μm, it can detect temperature differences of 0.12°C at 30°C, and has a field of view of 18° in the horizontal and 30° in the vertical. Thermal images are "photographed" through an open hatch in the helicopter floor. Color photographs are taken simultaneously to collate with the thermal images. In a more recent development, a helicopter-borne radiosonde system has been developed to make observations of pressure and dry- and wet-bulb temperatures (thermister thermometers). The soundings are used to compute the effects of atmospheric water vapor radiation upon the radiant emittance from the ground surface, using the radiative transfer equation. Both systems have been tested over Satsumaiwajima Island in southern Japan.

An invited paper by T. Tabata of the Institute of Low Temperature Science of Hokkaido University described surface radar observation of sea ice. Three radars were installed along the Okhotsk Sea coast of Hokkaido, the northern island of Japan. In winter, the Okhotsk Sea is almost entirely covered by ice. The radars were installed on mountain tops and a central controlling station was installed in 1969. The radars are 440, 300, and 220m above sea level. Time-lapse movies of the radar screen were shown. They constituted a dramatic and effective presentation of the movements of the ice, primarily under the influence of the local winds. The technique clearly demonstrated violent and complex motions of the ice. Photographic records permit the calculation of the deformation of the ice field in terms of divergence, convergence, and rotation (in degrees per hour). Several underwater current meters are now installed in the area, but there is little correlation between the water currents and the ice movement. This is not new work, but it represents the present status of ice cover recording in the region that was started in 1892. It also demonstrates an unusual, possibly unique, means of observing the response of sea ice to the wind.

The JAFSA project is the largest airborne remote sensing project in Japan and has an interesting home – the Japan Foundation for Shipbuilding Advancement – but it was under the sponsorship of the Blue Sea and Green Land Foundation from 1974 to 1975. Its main role is the development of remote sensing technology for use in a variety of fields. To date they have carried out more than 20 special experiments in such diverse fields as oil pollution, marine environmental studies, land use, vegetation, underwater topography, and observations of an active volcano.

The JAFSA remote sensing system includes both data acquisition and processing systems. Newly developed subsystems described in the paper are:

(1) A multispectral scanner MSS-BG-1. It is multispectral in the thermal IR ranges 4.3 to 5.5, 4.5 to 4.9, and 10.5 to 12.5 μm; spectral bands are changeable by replacing dielectric multilayered band pass filters.

(2) An onboard data acquisition system, which collects and synchronously records data from the MSS and from other instruments such as the altimeter, velocimeter, and the VLF navigation. The system also collects data on attitude (yaw, pitch, and roll), time, date and the gain and offset of the video amplifiers for the MSS signals.

(3) FMQL – FM quick looking system using FM.MT (FM recorded magnetic tape). This has a control console, a data recorder, a color display unit with buffer memory for 6 channels of data, and a micro-photography unit. Fast playback FMMT and high performance are important characteristics for image interpretation.

(4) A CCT converter converts FM recorded analog data into digital form and records it on magnetic tape. THE CCT-QL provides quick look image interpretation and field selection. It has color and monochromatic display units with memory for three channels of data, a character display unit, and it is connected with the IBM System 17. Image addition, subtraction and ratioing are provided by hardware; other functions, such as rolling up and down, zoom in and out, and rotation are by software.

It is interesting that the poster describing JAFSA was co-authored by scientists from the University of Tokyo, Toba Merchant Marine College, the University of Electro-Communications, the Institute of Color Technology of Chiba University, IBM Japan, and the Japan Foundation for Shipbuilding Advancement. Clearly JAFSA is multi-disciplinary, multi-institutional effort.

A final paper from Japan will be mentioned. It concerns attempts to apply satellite data to the saury fishery off northeast Honshu, in the confluence of the Kuroshio and Oyashio current systems. Sea-troth, fisheries data, and satellite data are being correlated in an attempt to use the latter to provide fisheries information. Commercial fisheries data (date, position, fishing methods, yield, catch per unit of effort, sea surface temperature) and sea-truth data (temperature, salinity, water color and transparency, experimental fishing yield, body length and body weight composition) were stored on magnetic tape. Several techniques were used to enhance the satellite information. Contrast stretching and ratioing methods showed a few coastal fronts; color and temperature gradients in the imagery made it possible to recognize water mass distributions. Correlations among the fisheries data, the ground truth, and

the satellite information are being investigated from all angles in an attempt to develop a system of fisheries forecasting services.

As the name implies, the Landsat satellites are designed primarily to look at the land from a high vantage point, with sensors designed primarily for detecting land features. The marine scientist looks forward to the products of the recently launched Seasat, with oceanographic features its primary objective. Another exciting development for the marine scientist is the Coastal Zone Color Scanner, mounted on the Nimbus G satellite. Prelaunch investigations give promise that this system will yield a wealth of information of biological interest that has never been available before. For one who did his thesis research on the analytical estimation of plankton pigments, this is an amazing jump from centrifuging the cells from a water sample, extracting the pigments, clarifying the extract, and finally estimating carotenoids and chlorophylls by a multichromatic spectrophotometric procedure. But it was a beginning that permitted us to establish some ground truth, without which much satellite imagery would be far behind its present state of usefulness.

JAPANESE ANTARCTIC RESEARCH

Francis A. Richards

The first Japanese expedition to the Antarctic (1910-1912) was organized by a retired Army Lieutenant, Nobu Shirase, and sponsored by one of the leading Japanese newspapers, *Asahi Shimbun.* The magnitude of the effort in no way compared with the contemporary expeditions of Shackleton, Scott, and Amundsen. The ship, the *Kainan Maru,* was only 204 tons but apparently stoutly built. The ship's company consisted of 16 men; there were 11 in the exploring party. Although the announced purpose of the expendition was to reach the South Pole, apparently no serious attempt to do so was made and the equipment and provisions were entirely inadequate for such a task. The expedition depended on manpower and 12 Siberian dogs for locomotion (the accounts of the number of dogs differ. The *Lyttleton Times* of Christchurch reported 12 Siberian dogs were aboard when the expedition called in New Zealand on its way to Antarctica, but on their return the Wellington, N.Z., *Times* said that 30 dogs had been taken down from Sydney and only six returned. "The rest, when no longer fit for work, were utilised to keep the survivors alive.")

After leaving New Zealand the ship sailed south, reaching 74°16'S, 172°7'E on 13 March 1911. Ice conditions forced her to return to Sydney where she stayed for six months (and picked up more dogs?). She then sailed to Antarctica through the Ross Sea, arriving on 19 January 1912. A land party reached 80°05'S, 156°37'W, exploring parts of the Ross Ice Shelf. The expedition is remembered by the name Shirase Coast which borders the Ross Ice Shelf between 75 and 80°S and 150-160°W, near Little America and Shirase Glacier, 70°10'S, 38°35'E. The Shirase Coast was given the name Yamato Yukihara (snow terrace or plain) by Shirase. The name Yamato (the old name for Japan) is now applied to a mountain range near Syowa Station, and the Shirase Glacier debouches into the Lűtzow-Holm Bay, on which Syowa Station is located. (Syowa is the official romanized spelling of this name, but the United States Board of Geographic names still uses Showa, which appeared on a cartographic map published by the Geographical Survey Institute of Japan during the International Geophysical Year, 1956-1957.) These features are on the opposite side of Antarctica from where the Shirase Expedition landed.

Major modern Japanese efforts in Antarctic research were initiated by their participation in the activities of the International Geophysical Year (1957-58). The First Japanese Antarctic Research Expedition (JARE) was dispatched in 1956 and established the scientific station Syowa on East Ongul Island (69°00'S, 39°35'E) on 29 January 1957. Since then, the station has been occupied continuously except between the years 1962 and 1965. The first helicopter arrived at Syowa 31 December 1965; the station was reopened on the following January 20.

Japanese Antarctic research was formerly a function of the Kyokuchi Kenkyu Senta (Polar Research Centre) attached to the National Science Museum, Tokyo.* It is now within the jurisdiction of Kokuritsu Kyokuchi Kenkyujo (National Institute of Polar Research (NIPR), established in September 1973, directly under the Ministry of Education, Science and Culture. The first (and Present) director is Professor Takesi Nagata, a geophysicist and Professor Emeritus from Tokyo University. His deputy is Professor Masayoshi Murayama, formerly director of the Polar Research Centre. The Institute occupies a new (January 1977) four story building (5796m^2) at 9-10 Kaga 1-chome, Itabashi, Tokyo 173, and another building (4000m^2) is planned – tentatively to be called the Administration and Research Materials Building.

The research is carried out within the departments of the Division of Research, headed by Professor Kou Kusunoki. There are six research departments in the division: Geophysics, Upper Atmosphere Physics, Glaciology, Solid Earth Sciences, Physiology and Ecology, and the First Section of Cryobiology. An unusual feature of the

*The embryo was Kyokuchigakka (Polar Section) of the museum, established 1 April 1962.

departments within the Research Division is that some of them are established to be filled by visiting faculty and staff, thus providing an unusual opportunity for the stimulus offered by visitors and for activities in areas not covered by the expertise of the permanent staff. These departments are Polar Meteorology, Polar Mineralogy and Economic Geology, The Second Cryobiology Department, and Polar Regions Engineering. Generally one professorship and one associate professorship are allocated to a department. Two chairs were allocated to upper atmosphere physicists for 1978. Also, one or two professorial positions are allocated to the leader of JARE if the leader belongs to another governmental organization.

Another unusual aspect of the Institute is that it has the status of a graduate school, essentially on a par with the graduate schools of the National Universities. Thus, the scientific staff members have professorial titles, direct the research of graduate students from the National Universities, and sit as members of graduate student supervisory committees. Of the many governmental research institutes in Japan, only seven have this status: the Institute of High Energy Physics; the Institute of Japanese Literature; the Museum of Ethnology in Osaka; the Institute for Molecular Science; and the National Center for Biology, which is composed of the Institute for Basic Biology and the Institute for Physiological Sciences.

The structure of the Institute for Polar Research is rounded out by the Division of Data Collection and Processing, the Office of Expeditions, the Office of Administration, the Library, and several boards that advise the director.

The Division of Data Collection and Processing, headed by Professor Tatsuro Matsuda, has departments of biological data, earth sciences data, data analysis, and low temperature materials. The staff of these departments carry out research in addition to their curatorial duties. Specimens and data collected over the years by the JARE have been scattered among the various parent universities and institutes of the individual participants. These materials are now being collected at the institute, where they will comprise a centralized data, sample, and specimen bank.

The biological specimens include exsiccated mosses, lichens, algae, and phanerogams; preserved specimens of fungi, mites, plankton, fishes, and benthos; and stuffed birds and marine mammals. An increasing collection of bryophytes is cataloged as a computerized data bank. The department's instruments include specialized desiccators, a universal microscope, and a scanning electron microscope with X-ray microanalyzer.

The Department of Earth Sciences Data is preparing various computerized catalogs of rock and meteorite collections, and of aurora, geomagnetic, and earthquake records. It is the repository of the articles left by the Shirase Expedition and of photographs and records taken by the JARE expeditions since 1956. In addition to the function of data acquisition, retrieval, and analysis, the Department of Data Analysis also carries out studies of data analysis methodology. Their principal computer is the medium sized HITAC M-160, which can retrieve Antarctic literature, including the JARE reports, the U.S. Antarctic Bibliography, and Current Antarctic Literature. Systems include POLDOR (Polar Document Retrieval System) and PDM – Practical Data Manager. The latter manages meteorological and gravity data, rock and meteorite samples, biological specimens, especially moss and lichen samples, maps, institutes, the names of researchers, and document distributions. Data quality control is also a responsibility of the department.

The Department of Low Temperature Material maintains and supervises low temperature research facilities for the preservation and analysis of materials collected in polar regions. Low temperature rooms are the main facility. The low temperature installation has a preparation room from which a vestibule and moisture trap, about $6m^2$ and $-10^{\circ}C$, is entered. The vestibule leads to a corridor-laboratory ($47.4m^2$) held at $-20^{\circ}C$. A $47.4m^2$, -20° laboratory, a sample storage area at $-25^{\circ}C$, and a $6m^2$ laboratory held at $-60^{\circ}C$ open off this corridor. The $-20^{\circ}C$ laboratory is cooled by natural convection; the other rooms are cooled by forced circulation of cold air. The facilities are open nationwide to universities and research institutions.

The Institute issues five publications:

1) *Nankyoku Shiryo (Antarctic Record).* Japanese and English. Irregular, three or four volumes each year.

2) *Memoirs of National Institute of Polar Research* (formerly *Japanese Antarctic Research Expedition Scientific Reports).* Irregular. Series A (Aeronomy), B (Meteorology), C (Earth Sciences), D (Oceanography), E (Biology), F (Logistics), and Special Issues.

3) *JARE Data Reports.* Irregular; several each year.

4) *Antarctic Geological Map Series* (two or three maps each year).

5) *Kyokuchiken Nyusu (News Bulletin of the National Institute of Polar Research)* in Japanese. Published every second month. The monthly climatic record of Syowa Station is included.

NIPR now has a staff of 101 permanent and 10 to 15 temporary personnel. This includes 31 members of JARE at the Syowa Station; all the people at Syowa are NIPR employees or governmental officials from other agencies, such as the Japan Meteorological Agency, either permanent or appointed temporarily for the duration of their participation in JARE. For example, a professor from a private university doing research in the Antarctic would be appointed as a temporary member of the NIPR staff.

The major Antarctic functions of the Institute are the scientific and logistic programs of the Japanese Antarctic Research Expedition – a continuing program that includes the manning and maintenance of two research stations – Syowa and Mizuho, an inland station occupied intermittently at (70°42'S, 44°20'E), and a small unmanned ground station for aeronomy and meteorological observations between Syowa and Mizuho. Several more such unmanned stations will be established during the POLEX program in 1979-1981. The 31 people occupying these stations include scientists, two medical doctors, radio operators, technicians, field assistants and cooks. The stations are serviced and parties are exchanged by the icebreaker *Fuji,* 7,760 displacement tons, carrying 240 men, including up to 40 expedition members; she can also carry 500 tons of cargo and three helicopters. The *Fuji* goes to Syowa in the Antarctic spring and stays two or three months, during which time the crew is engaged in maintenance, supply, construction, and other logistics work. The *Fuji* is owned and operated by the Self Defense Agency and succeeded the smaller icebreaker *Soya,* which operated between 1956 and 1962. She was built during the period Syowa was closed (February 1962 to 1965). A new icebreaker to replace the *Fuji* is planned, with construction to start in 1979. She will be about 11,000 tons displacement, 110 m long and will accommodate a crew of 150 and 60 scientists. The laboratory space will be twice that on the *Fuji,* and she will carry one small and two large helicopters. She will be well equipped for oceanographic work. Syowa station has some 20 buildings, 40 vehicles, and two power generators (65 kva and 45 kva).

The NIPR has also operated the Japanese part of the international Dry Valley Drilling Project (DVDP) – a cooperative effort of Japan, the United States, and New Zealand. This project is phasing out after having drilled 15 corings in the Dry Valley Region (ca 75°S, 160°E), but a follow-up program, provisionally named the McMurdo Sound Sediment and Tectonic Study, is planned. Both programs are multidisciplinary, international, and largely concerned with geology (New Zealand), geophysics (United States), and geochemistry (Japan). A symposium on the results of the DVDP project and a planning session for the new program were held in Tokyo in June 1978. The main activity of the institute in the DVDP has been in the areas of administration, logistics, and geological study. Most of the Japanese effort in the DVDP has been in the field of geochemistry and has been carried out by scientists from various university and government laboratories.

The Institute has also been responsible for Japanese participation in other international programs, including the United States-Japan Meteorite Search Project and the International Magnetospheric Study. In addition, scientists from the Institute have participated in the Antarctic expeditions of other nations during austral summers under the agreements of the Antarctic Treaty. For instance, in the summer of 1978-1979 a Japanese biologist will join the Chilean expedition to the Antarctic Peninsula. Such participation is officially decided upon by the Headquarters of JARE, chaired by the Minister of Education, Science, and Culture.

Japan is heavily involved in the International Magnetospheric Study (IMS) – a cooperative program with the United States. The IMS program in Japan has two parts. One is carried out in Japan and included the launching of

the scientific satellite EXOS-A (Kyokko) in January 1978 from the Kagoshima Space Centre as well as other magnetospheric observations. The Antarctic program includes the launching of rockets and large balloons from Syowa Station, simultaneous observations using ground based facilities at Syowa, Mizuho, the unmanned station, and at its magnetically conjugate point near Reykjavik, Iceland. The ground observations include aurora, ULF, HF, geomagmetism, etc. The IMS has included simultaneous observations at Syowa, its conjugate point near Reykjavik, and in northern Norway. Japanese scientists from the Polar Research Institute visited Reykjavik in 1977 and 1978 and Norway in 1976 to participate in these observations.

Syowa Station has data acquisition facilities for receiving telemetered signals from satellites. "Top-side sounding" (sounding the ionospheric layer from above) data from ISIS I and ISIS II satellites, launched by the Canadian Research Council and National Aeronautics and Space Administration (NASA), are received at Syowa. Variables include changes in electron density and electromagnetic waves. These measurements are augmented by the GEOS Satellite, a European (primarily French and German) instrumented geostationary satellite in orbit at the equator at an altitude of 36,000 km. Many other satellites observe the magnetosphere from above, some from within it. Syowa Station also records data from the meteorological satellites NOAA III, IV, and V. During the IMS (1976-1978) ground observation facilities at Syowa and Mizuho were augmented specifically for the study; the number of scientists involved was also increased.

The magnetosphere measurements are in conjunction with regular ground observations at Syowa Station. Sounding rockets are launched from Syowa - the only Antarctic station where rockets are launched. Two types are used, both with solid propellant motors. The smaller, the S210 (210 is the diameter of the motor in millimeters) reaches an altitude of 130 to 140 km. The S310 is designed to reach more than 200 km. The launches are followed by two radars – one for tracking, the other for receiving telemetered data. The rockets are instrumented to measure electron density, electromagnetic waves, and X-rays. About six rockets are launched each year, mostly in the Antarctic winter during intense aurora.

The IMS is coming to a close, but two members of the Upper Atmosphere Physics Department plan to spend four months in the latter half of 1978 in Iceland participating in the program.

An interesting joint Japan-United States program in the Antarctic is the Meteorite Search. Searches have been carried out in the Yamato Mountains and in part of Victoria Land, and both areas have yielded several hundred meteorites of widely varying sizes and shapes. The largest found to date is the Allan Hills No. 9 (Chondrite) 400kg meteorite found in Victoria Land. Most of the meteorites are chondrites – only two iron meteorites have been found in the Yamato Mountains. The meteorites have been found in ice-free areas of the Yamato Mountains, in the Dry Valleys, and in the ice fields of Victoria Land. Landsat imagery has been used to locate promising blue ice fields. Areas of high and of low concentrations of meteorites exist, but why they do is not understood. Meteorite showers may be localized by some unknown process, or the meteorites may be concentrated from a "watershed" by some process of ice movements.

The meteorites are examined for their geochemistry, mineralogy, petrology, and rock magnetism. This phase of the work is aimed at describing the properties of the meteorites and the distribution of those properties. The ultimate goal is cosmological and the understanding of the origin of the universe.

Biological investigations are restricted by the rather simple nature of the ecosystem that can persist under the severe conditions of Syowa Station. There are rookeries of Adélie penguins whose droppings enrich the surface. In the brief period when any liquid water is about, algae, mosses and lichens can grow. Some protozoa, mites, and springtails can survive the harsh terrestrial environment, but not much else can.

The penguins themselves move to the ice edge in winter, returning to the shore rookeries in October. The female lays one or two eggs and the male and female share the duty of incubating them until they hatch in late December. The chicks remain in the rookeries and are fed by the parents during December and January. Not long afterward the chicks walk out to the ice edge to feed. Adélie and Emperor penguins are neighbors of Syowa Station, but other species occur farther north on the Antarctic Peninsula and in other areas.

The Japanese are considering participation in the International BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) program. Routine physical, chemical, and biological observations made aboard the *Fuji* on her way to and from Syowa Station may contribute to this program. The standard oceanographic station includes a salinity-temperature-depth (STD) recorder cast, temperature, salinity, dissolved oxygen, phosphate, nitrate, nitrite, silicate, ammonia, and chlorophyll determinations, and plankton hauls from 200m to the surface with two or three different kinds of plankton nets. Ten such stations may be occupied between Freemantle and Syowa Station. After offloading, *Fuji* occupies 10 or 12 stations in the vicinity of Syowa Station. In the 1977-1978 season it was planned to occupy such stations to and from 50°S, but the *Fuji* got stuck in the ice and had to abandon the project. Observations into the Indian Ocean are planned for the future.

The Japanese involvement in the BIOMASS program is especially concerned with the estimation of the biomass of the Antarctic krill, *Euphasia superba.* In addition to these estimates, they are also working on the life history and reproductive physiology of the krill. The sampling program, supervised by the Fisheries Agency of the Ministry of Agriculture and Forestry, is carried out from 10 experimental fishing ships that are sent to the Southern Ocean to catch krill.

Special sampling programs may be carried out aboard the *Fuji.* For example, some years ago Dr. Yukio Sugimura of the Geochemical Laboratory of the Meteorological Research Institute collected large seawater samples aboard the icebreaker for studies of uranium distribution. Other programs have been carried out including shipboard gravity measurements, radiowave propagation and atmospheric nuclei studies, air gun seismic profiling, and cosmic ray observations, but these programs are quite limited by the lack of time. *Fuji's* principal mission is logistic.

The analysis of meteorological data observed at Syowa and the other Antarctic Stations and synoptic meteorology are part of the meteorological program, and Syowa has its own meteorological satellite receiving station.

The major meteorological problem in Antarctica is the role of the continent in the heat balance of the earth and the function of Antarctica as a heat sink. Defining the radiation balance is of primary interest. An important part of the heat balance studies is concerned with the atmospheric ozone layer and its effect on radiative heat transfer. The Dobson interferometer, a standard instrument for estimating ozone in the atmosphere, is carried aloft some 10 times a year by balloon sonde and two or three times a year by sounding rockets. Of particular interest in this program is the annual sudden warming of the troposphere and its causes. Each year, usually in September or October, the temperature in the troposphere (20 km up) suddenly warms from -50 to -60°C to about -20°C. This could arise from a change in the ozone layer, it could be due to the return of the sun to these latitudes with accompanying photochemical reactions, or ozone-rich air masses may intrude and induce a greenhouse effect, similar to the expected effect of increased carbon dioxide.

It is evident that the Japanese look to the Antarctic as an eventual source of living and mineral resources. Their effort in polar research is significant, with the main emphasis on the Antarctic. They maintain a first class research institute with modern buildings, equipment, and library. The Institute has a staff of around 100 in scientific, logistic, and administrative support of one major and two lesser Antarctic stations, which are manned by around 30 people. A large icebreaker, carrying a crew of 200 and up to 40 expedition members, is dedicated to the research, and a new, larger one is planned. There is major Japanese participation in international research programs such as the Dry Valley Drilling Project, BIOMASS, the International Magnetospheric Study, and the United States-Japan Meteorite Search. Many Japanese universities and other government laboratories also have staff and faculty members who are active in Antarctic research. It is an impressive overall program being carried out by competent and dedicated scientists.

Syowa Station, Antarctica, February 1978
(Photo courtesy of the Japanese National Institute of Polar Research)

THE MARINE SCIENCES CENTER, UNIVERSITY OF THE PHILIPPINES, QUEZON CITY

Francis A. Richards

The establishment of the Marine Sciences Center of the University of the Philippines was approved by the Board of Regents in 1974 and the Center began regular operations in February 1975. At that time the Center consisted of a two-page charter from the university and a young, enthusiastic, newly hired acting director, Dr. Edgardo D. Gomez. With little of either space or money, Dr. Gomez began to put together a staff and research program that, at the end of one year, had three research projects under way; it now has grown to a group of 23 academic non-teaching staff and five administrative staff. In addition, there is an "attached project" staff of 21 faculty members that spends part time with the center. Of the senior research staff, there are nine with Ph.D. degrees, five with master's degrees, and one with a B. S. Three Research Associates hold master's degrees, all the others have their bachelor's degrees. University support was about 400,000 pesos in 1977. Although not reflected in the current exchange rate, the domestic buying power of the peso is roughly equal to that of a dollar in the United States. In addition to the university funds, in 1977 the center received external grants of around 2,000,000 pesos, primarily from the Department of Natural Resources, secondarily from the National Science Development Board. They also received a small grant from the Sweden-based International Foundation for Science; this grant was used to purchase equipment for high pressure liquid chromatography.

The Marine Sciences Center is an independent research institute on the main Diliman (Quezon City, Metro Manila) campus of the university. The university itself is organized somewhat like the University of California, with several semi-autonomous campuses. The Diliman campus is by far the largest, with approximately 3/4 of the undergraduate enrollment of nearly 30,000 and a graduate enrollment of around 4,700. Other campuses are the U.P. Los Banos (the second largest), U.P. College Baguio, U.P. College Cebu, U.P. College Tacloban, U.P. Extension Division Clark Air Base, U.P. College Iloilo, and U.P. College Manila.

Although the Marine Sciences Center as such now has no teaching duties, they may take on such duties in the future. The part time faculty members associated with the center teach in their parent departments, primarily Zoology, Botany, Geology, and the College of Medicine. Courses in the College of Arts and Sciences lead to the Bachelor's degree in Marine Science and Master's degrees in Marine Biology, Marine Geology, and Oceanography. Oceanography is taught primarily in the Department of Meteorology and Oceanography.

Dr. Gomez took his Ph.D. from the University of California, San Diego, Scripps Institution of Oceanography, where his research was on Conopean Balanids (barnacles) under the direction of Professor W. A. Newman. With this background and the practical needs of a developing country such as the Philippines, it is not surprising that the research of the center is almost exclusively in various aspects of marine biology, specifically studies of corals and seaweeds. Both offer research challenges and both are economically important.

Several of the center's projects are devoted to various aspects of the study of seaweeds. Marine algae are cultured rather extensively in the Philippines, nor primarily for direct human consumption as is the case in Japan, but as the raw material for a large variety of commercially important products derived from seaweed. Alginin and other algal polysaccharides are used in foods, cosmetics and toothpaste, the sizing of paper, the preparation of mucilage and glues, as a clearing agent for beer, and as wire insulating material. A major project of the center under the direction of Ms. E. V. Laserna is concerned with seaweed processing technology. There is a small new pilot plant for the experimental production of carrageenan and other polysaccharides, and there are other laboratories for studying their biochemical, chemical, and physical properties. Studies are under way to relate the trace metal contents of the products to their physical properties such as gel strength and viscosity. The trace metals are also good pollution indicators; the polysaccharides are highly sulfated, so they readily take up trace metals from the environment.

Somewhat more basic research is being carried out on the enzymes that digest polysaccharides, as well as attempts to isolate sterols and insulin-like substances.

The marine products research laboratory is well equipped and housed in a new building constructed for the purpose. Among other equipment they have an Hitachi Grating Infrared Analyzer, an Hitachi UV-VIS spectrophotometer, a good lyophilizer, Waters high pressure liquid chromatography equipment, and a Varian atomic absorption spectrophotometer with tubes for the determination of sodium, mercury, lead, arsenic, and cadmium.

The principal algae cultivated in the Philippines are *Eucheurma striatum* and *E. spinosum* although a *Gracilaria* species is cultured in Manila Bay for food agar. The algae are farmed in areas only 1½ to 6 feet deep, areas that are shallower and circulate less well than the natural habitats. Frequently the thalli become infected by bacteria and decompose. Dr. Flordeliz Uyenco, who holds joint appointments in the Marine Sciences Center and the Department of Botany, is studying this problem and has now isolated at least three different genera of bacteria that infect the algae. It is believed, however, that the difficulty arises more from environmental factors, such as poor water circulation, high temperatures, and low salinities, than from bacterial disease. Dr. Uyenco, a graduate of Michigan State University, is also carrying out yeast protein studies.

Sea urchins also eat the algae, and sea urchin enzymes are being studied as are the mechanisms by which they prey on the algae. Presumably they contain a specific enzyme, carraginase, and understanding the enzyme could lead to synthetic enzymes that might be used in making algal polysaccharides more useful.

Dr. Gavino C. Trono, Jr., who took his degree at the University of Hawaii, is a specialist in algal taxonomy, ecology, and agronomy. He holds a joint appointment with the Botany Department. His principal project now is the preparation of an *Illustrated Manual of the Seaweeds of the Philippines.* The manual will contain not only taxonomic descriptions and scientific illustrations of the algae but will also cover their distribution, economic status, and ecological situation. The work on some 50 species has now been completed; the descriptions are beautifully illustrated by carefully delineated hand drawings from natural specimens.

Dr. Gomez is involved in studies of the reproductive biology of sea urchins, specifically *Tripneustes gratilla* and *Diadema setosum.* He is carrying out histological, ecological, and environmental studies (water temperature, salinity, pH) and observations of the gonad index [= (gonad weight/total body weight) x 100] for the very practical reason that sea urchin gonads are considered a delicacy in Japan and elsewhere. Japan now imports large quantities of the California sea urchin, *Strongylocentrotus franciscanus,* so the Philippine sea urchins have good export potential. (It is an interesting ecological sidelight that the California sea urchin is now apparently filling an ecological niche left vacant by the virtual disappearance of the abalone, which appears to be partly the result of the protection and reestablishment of the sea otter, which seems to enjoy abalone as much or more so than the Japanese enjoy "sea eggs," sea urchin gonads).

A project attached to the Marine Sciences Center from the Philippine Bureau of Fisheries and Aquatic Resources concerns mussel farming. The project includes laboratory studies of histology and reproductive physiology. Phytoplankton cultures have been started to serve as food for the mussels, and mussel larval culture is being considered.

The studies on sea urchins and mussels are secondary in emphasis to the algal and coral studies at the Marine Sciences Center. Coral is a major export of the Philippines, and if one buys coral in Miami or Hawaii to put in his aquarium, add to his collection, or to display on the mantlepiece, the coral probably came from the Philippines. So the biology of corals is of particular significance in the Philippines.

The coral research was begun by collecting literature on corals and now the main concern is a resource survey and the preparation of topographic maps showing in detail the distribution of corals in the Philippines. The survey is being carried out by three teams of scuba divers, one based at the university, one at Cebu, and one on Negros Island. There are two or three full time divers on each team, and Dr. Gomez considers himself a regular diving member of the university team.

Transects and quadrats are established and the coral populations are described quantitatively and qualitatively. The questions they seek to answer are what are the possible causes of destruction or damage to the corals; what effect does the exportation of tons of corals have, not only on the corals themselves but on the reefs as habitats for fishes; how long does recolonization require; what are the effects of dynamite fishing (illegal but prevalent nonetheless) on the corals; what damage is done by natural predation and siltation; and what is the devastation arising from increased siltation resulting from forest denudation? The work has just begun, but in the first six months of the project the three diver teams covered 250 stations; the project is now in phase two, and 150 stations have been covered in the first five months of this phase.

The director of the center wants to undertake similar research on the deep-living precious corals, but the project has not yet been funded. Because of the depths at which these corals live, different techniques will be required, possibly underwater photography. Incidental to the coral research, an evaluation of sites for Marine Parks is being carried out.

It is evident that the Philippines are a rich area for marine research. The Marine Sciences Center has made an impressive beginning on a number of significant projects, but the staff and facilities are pretty well saturated with work. More space is badly needed; only the Marine Products laboratory seems adequately housed. There is a proposal to move the College of Fisheries from the Diliman campus to Iloilo. Were this to take place, the Marine Sciences Center would inherit the space occupied by the College of Fisheries. This would do much toward solving the space problem.

Acquiring qualified staff is another problem. The group is now strong in marine biology, but qualified people are needed to develop programs in chemical and physical oceanography and in marine geology. Adequate funding remains difficult. The U. S. AID program may extend technical assistance and help in procuring equipment, but not salaries or buildings. Other sources of funding, such as the U. S. International Sea Grant Program and the World Bank, are being explored.

The center now has no research vessel, relying on rented fishing boats. The College of Fisheries operates the fisheries training vessel *Albacore*, which is used from time to time by personnel from the center.

The establishment of marine laboratories along the coast is projected. The Center has been given a five hectare site in Bolinao on the west end of Lingayen Gulf and other sites for marine stations have been suggested. Given the geography of the Philippines it is obvious that any single station could cover no more than a small part of the complex marine ecosystem.

In November, 1975, a UNESCO Advisory Mission on Marine Science visited many of the marine installations of the islands and made certain recommendations. The writer understands that the final report of the Mission was received in Manila in April, 1978, but he has seen an early draft of the report. Among the draft recommendations is one for the establishment of a Philippine Journal of Marine Science as a means of communication among Philippine marine scientists and as an outlet for scientific papers. Some journals are now published in the Philippines. *Kalikasan*, The Philippine Journal of Biology, is in its seventh year of publication. It carries papers on original research in biology, which it accepts from any nation. Technical reports are issued by the Natural Science Research Center; the Bureau of Fisheries and Aquatic Resources publishes the *Philippine Journal of Fisheries*, and the Fisheries Research Society of the Philippines issues the *Fisheries Research Journal of the Philippines*. In view of the fisheries orientation of the last three named publications, the writer heartily joins in the recommendation for a journal of Marine Science.

PEOPLES REPUBLIC OF CHINA OCEANOGRAPHIC RESEARCH VESSEL *SHIJIAN*

Francis A. Richards

The Fifth International Ocean Development Conference was held in Tokyo 25-29 September 1978. As part of their first participation in these conferences, the Peoples Republic of China sent the Oceanographic Research Vessel *Shijian* to Tokyo and put her on public display. Tours of the vessel were conducted twice a day for four days; tour groups were limited to 25. A young and affable Chinese-Japanese interpreter accompanied the groups. The writer posed a special problem, but a competent Chinese-to-English interpreter was introduced; he helped bridge the language and technical gaps.

I was given a small booklet (in Chinese and English) containing the basic data about the ship. She is steel hulled, direct drive diesel, twin screwed, and has a cruising radius of 7,500 nautical miles and an endurance, determined by her fuel capacity, of 45 days. Evaporators provide fresh water. Length overall: 94.73m; length between perpendiculars 87m; beam 14m; designed draft 4.75m; designed displacement 2,955 tons; maximum speed 16.23 knots; economical speed 14.5 knots; "free running speed" (propelled by the active rudder) 3.75 knots; main engines 6ESD (Z) 43/82, 2 x 2000 HP; auxiliary engines CD6250, 4 x 450 HP; main generator CFH-250-6 4 x 250 KW; emergency generator Z2C-92 1 x 65 KW; electrical system 230 V DC. The complement of 117 includes 64 scientists.

The winches were covered, as were the deck guns, but 11 oceanographic winches are listed: upper deck, port side, 12,000-m deep-sea winch; two shallow water (1,2000 m) winches, port and starboard; three "electric cable" winches; two 6,000-m medium winches, port and starboard; two 1,200-m shallow water winches, port and starboard; and one 13,700-m benthic trawl winch on the aft platform deck. Eight laboratories are listed; at least one of these, the microbiological laboratory, has never been used for the designed purpose.

My tour of the ship started, conventionally, in the rather conventional wheel-house. The two radars were apparently Chinese built, but the Loran was Japanese. The air conditioned ship is equipped with an autopilot and the usual navigational echo sounders. There is no satellite navigation equipment but she can receive and record satellite cloud cover data; I was unable to determine the satellite source of these data.

The hydrological laboratory had a variety of current meters on display; these included a Savonius rotor type recording meter, a direct reading current meter good to 100 m, and an electromagnetic current meter. There was also a direct reading thermo-salinograph.

I was surprised to see a Chinese-made version of the Spilhaus-Miller multiple sea-sampler. This is an instrument that has 12 samplers, each holding a few hundred milliliters, riding piggy-back on a Spilhaus mechanical bathythermograph. In the early 1950's I spent a couple of weeks at sea trying to use a prototype of the instrument for collecting oxygen samples, so I was curious about the Chinese experience with it. I learned that it was used only for collecting salinity samples, for which it was initially designed, and for this use it appears to be satisfactory. The instrument seemed to be well contructed. The original Spilhaus-Miller idea was a good one, although soon supplanted by the STD, CTD, and continuous oxygen recorders.

The "hydrochemical" laboratory seemed rather barren to me; I was not shown sampling equipment, so I was unable to evaluate their wet laboratory and sampling capabilities. The laboratory did have an induction salinometer, which looked much like the Neil Brown instrument. I was told it was built in Tientsin by the Research Institute of Marine Instrumentation, part of the National Bureau of Oceanography, which is based in Peking. The laboratory also included a dissolved oxygen meter built at Amoy University. I saw no equipment for Winkler oxygen determinations. There was an instrument called an "optical-electro-bactophotometer" that seemed to do the job of turbidimetric

measurements that has been done by the Klett photometer for years. The instrument was built at Fukien Provincial University. A pH meter designated HSP_1 was built at Amoy University.

The ship is now outfitted for upper layer physical oceanography and meteorology in preparation for her participation in GARP (Global Atmospheric Research Program of the World Meteorological Organization and the International Council of Scientific Unions). The Chinese will be concerned both with observation and data correlations. The *Shijian* is equipped with wave recorders and a GEK, although the latter will not be useful in the low latitudes of the GARP experiment. An important part of her program will be the launching and monitoring of radiosondes; the balloons are hydrogen filled and the ship has a special hydrogen generating room. The participation of *Shijian* in GARP consists of two-month cruises in the equatorial central Pacific; she will operate out of Fiji.

The ship was particularly well equipped for meteorological observations and for the receipt and transmission of meteorological data. I was told that she had conducted seismic observations in the past, but the present emphasis is on GARP; I saw no instrumentation for geophysical measurements. There was an impressive array of teletype-writers for receiving and sending meteorological data and a large room for preparing weather maps. One laboratory housed two facsimile recorders for meteorological data and in another there was a recording barograph and wind speed and direction recorder.

Shijian was built by the Hudong Shipyard in Shanghai in 1968. She is now assigned to the East China Sea Sub-bureau of the National Bureau of Oceanography. In 1974 she participated in surveying the route for the Sino-Japanese submarine cable.

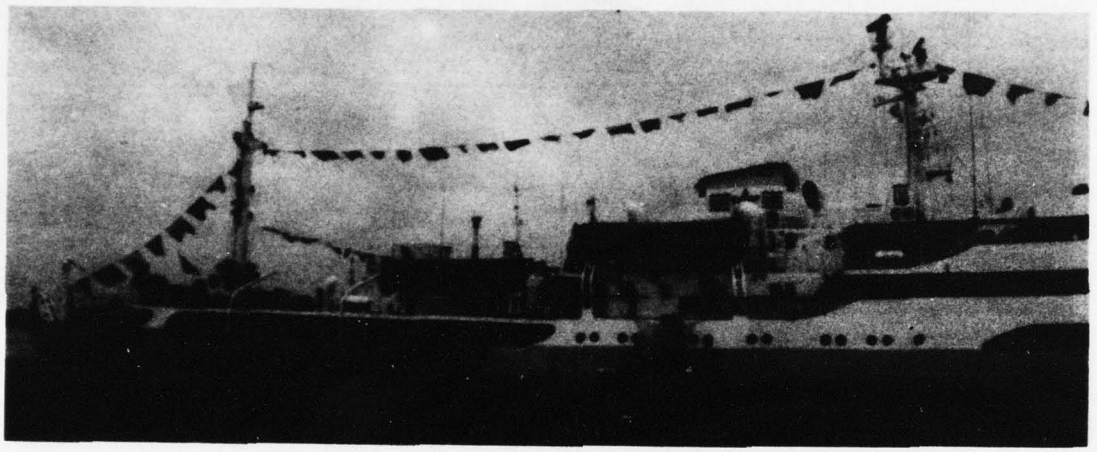
I was told that the ship is equipped for conventional hydrographic casts and uses Chinese made deep-sea reversing thermometers. These are calibrated in Shanghai, where high pressure tanks are available for determining pressure factors.

One cannot judge a book by its cover, especially when one is illiterate in the language of the cover. Although I saw no evidence of any advanced technology, the *Shijian* appeared to be a well-built, well-founded, well-maintained and competent research tool.

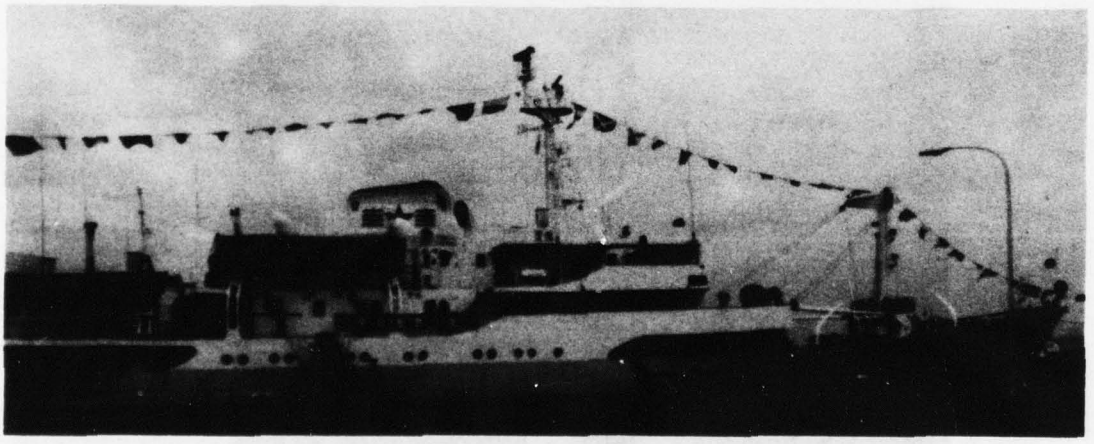
The ship is owned and operated by the National Bureau of Oceanography; her home port is Shanghai. The bureau has three geographical sub-bureaus for the North China Sea, the South China Sea, and the East China Sea. The bureau also coordinates oceanographic research at universities and other oceanographic laboratories and operates five institutes: the First Research Institute of Oceanography at Tsingtao, the Second Research Institute of Oceanography at Hangchow, the Third Research Institute of Oceanography at Amoy, the Institute of Marine Instrumentation at Tientsin, and the Institute of Marine Scientific and Technological Information – a data center.

In addition to *Shijian* the Bureau of Oceanography operates three other ships, *Hsiangyangung* (or *Shiangyanghong) No. 5* and *No. 9* and the *Tungfanghong*. The No. 5 is 10,000 tons, and apparently the No. 9 is of similar size. Bertil Ostrom (Marine Research in China, Nature, *267*, 794-797, 1977) also mentioned the research vessel *Red Star*, 66 meters long, 11 meter beam, 3.7 m draft, 1,500 tons dead weight, endurance 3 weeks, complement of 35 (crew and scientists). Ostrom indicated that the *Red Star*'s home port is Kwangchow and that she operates primarily in South China Sea. The South China Sea Institute (Sub-bureau?) of Oceanography is the operating agency.

PRC OCEAN. RESEARCH VESSEL SHIJIAN – F. A. RICHARDS

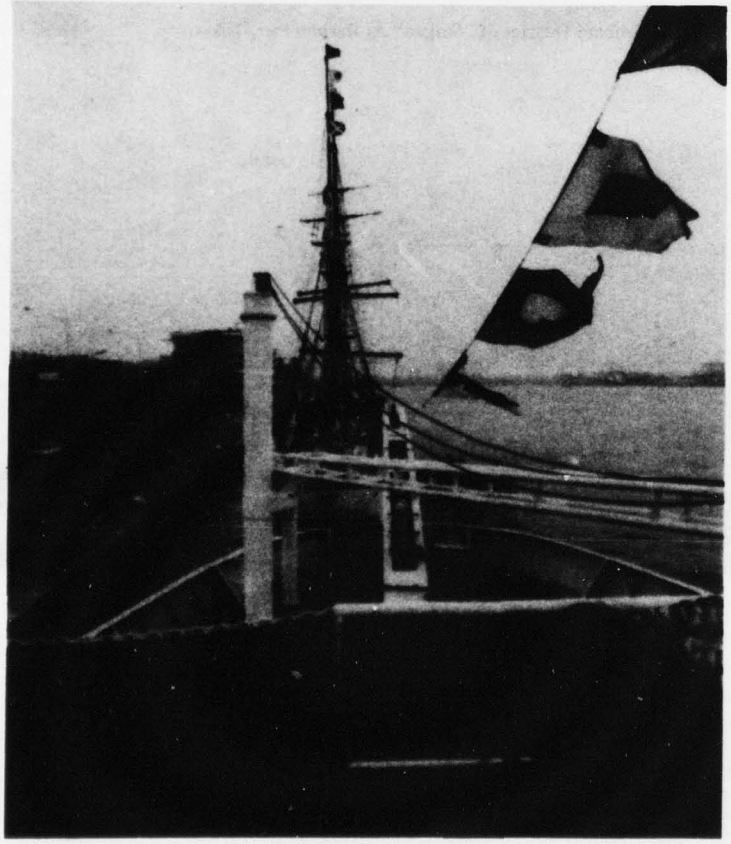


Starboard Quarter of "Shijian" At Harumi Pier, Tokyo



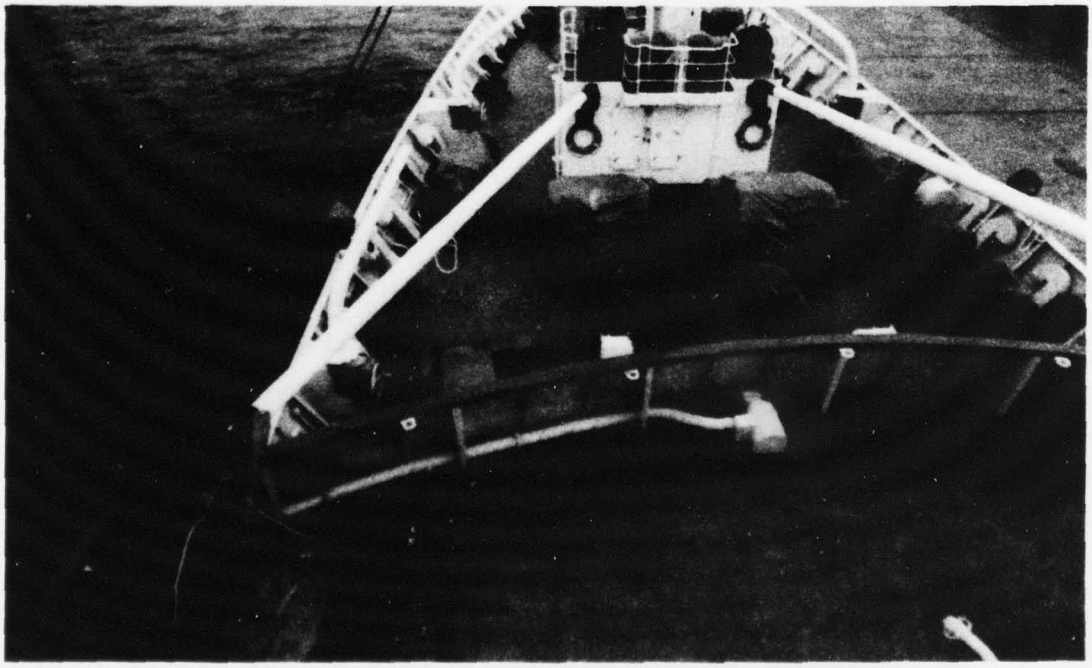
Starboard Bow of "Shijian" At Harumi Pier, Tokyo

(From Right to Left) Mr. Cheng I-fang, Director of the "Shijian's" Laboratories; F. A. Richards; Captain Hsu Nai-ching, Master of the "Shijian"; and the Chinese-English Interpreter.



Stern of "Shijian" At Harumi Pier, Tokyo

Mr. S. Sakiyama, ONR-Tokyo (Right) And Chinese-English Interpreter on the "Shijian"



Foredeck of the "Shijian"

RESEARCH AND SURVEY SHIPS IN JAPAN

Francis A. Richards

The author recently received a copy of Jane's Ocean Technology 1978 (R. L. Trillo, editor, Macdonald and Jane's, London, 1978, 820 pp) and was surprised, on turning to the Research and Survey Vessels section, to find only nine Japanese vessels listed. All those listed are operated by government agencies, and neither the well-known *Hakuho Maru* of Tokyo University nor the *Oshoro Maru* of Hokkaido University was included. Dr. Yoshio Sugiura, Director of the Geochemical Laboratory of the Meteorological Research Institute, Koenji, Tokyo, kindly furnished me a listing of Japanese research and survey ships (Table 1). The list may not be fully complete, but there should be no major omissions. I wish to thank Dr. Sugiura for his kind help.

Tables 2 and 3 have been prepared for comparison with similar statistics for the United States Oceanographic Fleet published by Mulcahy (M. Mulcahy, A time for decision on the federal oceanographic fleet, Sea Technology, June 1976). Table 2 lists 34 Japanese ships versus Mulcahy's listing of 81 for the United States. But in the Japanese fleet no ship is over 25 years old and all but 4 are less than 20 years old; in the United States fleet 26% are more than 25 years old.

Japanese seldom refer to a ship's length, always to its tonnage, so it is difficult to compare the sizes of the ships in the two fleets, but the Japanese seem to prefer 300 to 400 tonners. The academic fleet in Japan (9) is 26% of the total number; the UNOLS (University National Oceanographic Laboratories System) fleet is 35% of the United States fleet. (These numbers are also not quite comparable. The UNOLS fleet consists of federally funded vessels operated by the academic community. Two of the Japanese university ships are privately funded.

In addition to the Research and Survey vessels in Japan there are many prefectural experimental fisheries vessels and many of the coastal prefectures operate fisheries high schools and associated training ships. Some of these ships make oceanographic observations and are required to submit the data to the Fisheries Agency.

JAPANESE RESEARCH AND SURVEY VESSELS

Name	Tonnage		Service Speed	Propulsion	Cruising range		Complement		Laboratories	Year built	Owner/Operator
	Displ.	Gross	(knots)	(HP)	NM	Days	Officers & Crew	Scientists			
Operated by the Self-Defence Agnecy for the National Institute for Polar Research											
Fuji	5250	-	16.0	12000	-	-		200	-	1965	Self-Defence Agency
Meteorological Agency											
Keifu Maru	2221	1796	14.0	2400 PS x 2	10000	35	40	20	6	1969	Japan Meteorological Agency
Ryofu Maru	2082	1599	13.0	3260	15000	40	38	19	2	1966	- " -
Chofu Maru	486	266	10.0	500	6000	25	23	15	1	1960	Nagasaki Marine Observatory
Kofu Maru	536	346	11.0	650	7000	34	26	15	1	1963	Hakodate Marine Observatory
Seifu Maru	569	355	11.0	650	6600	34	26	15	1	1964	Maizuru Marine Observatory
Shunpu Maru	610	360	12.0	750	6000	15	26	13	2	1974	Kobe Marine Observatory
Maritime Safety Agency											
Heiyo	67	51	6.0	150	670	3		12	-	1955	Maritime Safety Agency
Kaiyo	378	310	11.0	450	4700	25		34	1	1964	- " -
Meiyo	490	360	10.0	700	5200	22		40	1	1963	- " -
Shoyo	1950	1900	14.0	2400 x 2	12000	40		73	2	1972	- " -
Takuyo	853	771	12.0	650	8270	33		50	2	1957	- " -
Tenyo	181	121	9.0	230	2800	13		25	-	1961	- " -
Fisheries Agency											
Shoyo Maru	2130	1378	14.5	2000	10000		41	7		1972	Japan Fisheries Agency
Tenyo Maru	851	518	11.0	1000	8000	30	30	2	1	1964	- " -
Kaiyo Maru	3931	2539	14.0	-	15000	50		76	2	1967	- " -
Koyo Maru	1800	1215	13.0	1800	15000	50	45	3	1	1958	- " -
Hokukko Maru	384	220	11.0	550	7500	-		29	-	1960	Hokkaido Regional Fisheries Research Laboratory
Hokushin Maru		219	13.5	1000	-	-		25	-	1965	Kushiro Fisheries Experimental Stn.
Mizuho Maru	135	77	9.0	260	2000	-		17	-	1962	Japan Sea Regional Fisheries Research Laboratory
Shunyo Maru	840	393	13.0	1300	6000			29	-	1973	Far Seas Fisheries Res. Lab.
Shirafuji Maru	123	96	10.0	500	3000	-		16	-	1965	Nansei Regional Fisheries Res.Lab.
Wakataka Maru	269	143	10.0	510	1700	-		20	-	1970	Tohoku Regional Fisheries Res.Lab.
Soyo Maru	835	404	13.0	800	8000	-		35	-	1970	Tokai Regional Fisheries Res. Lab.
Yoko Maru	355	213	9.8	550	6000	20		30	-	1961	Saikai Regional Fisheries Res.Lab.
Metals Mining Agency - Geological Survey											
Hakurei Maru	-	1821	15.0	-	15000	-	35	20	5	1974	Metal Mining Agency of Japan
National Universities											
Hakuho Maru		3226	17.7	4400	15000		55	32	9	1967	Ocean Res. Inst., Univ. of Tokyo
Tansei Maru	478	258	10.0	550	7500	30	27	10	30m^2	1963	- " -
Hokusei Maru		273	10.0	600	9600	30	23	24	-	1957	Hokkaido University
Oshoro Maru	1808	1180	12.5	2000	11000	45	100	6	2	1962	- " -
Kagoshima Maru	635	1200	12.5	1700	12900	43	42	53	21.7m^2	1960	Kagoshima University
Nagasaki Maru		563	11.0	1200	-	-	31	50	-	1964	Nagasaki University
Shinyo Maru		380	11.5	880	8500	30	22	2	1	1963	Tokyo University of Fisheries
Private University											
Tokai-Daigaku Maru II	-	703	13.3	1400	4000	-		124			Tokai University
Bosri Maru	-	1103	13.0	2400	15000	-	32	8	-	1953	Tokai University
Industry								(80 students)		(remodeled 1971)	
Wakashio	450	368	9.0	360 PS x 2	3000	-	10	13	-	1971	Fuyo Ocean Development & Engineering Co. Ltd.

Table 1: Japanese Research and Survey Vessels

Table 2: Japanese Research Survey Fleet Age

Operator	>25 yrs. old (built before 1953)	20-25 yrs. old (built 1953-1957)	10-20 yrs. old (built 1958-1967)	<10 yrs. old (built since 1968)
Self Defence Agency			1*	
Meteorological Agency			4	2
Maritime Safety Agency		2	3	1
Fisheries Agency			8	4
Metals Mining Agency				1
Universities				
National		1	6	
Private		1		1
Industry				1
Total	0	4	21	10

Ships of Prefectural Institutions not included.
*This is the icebreaker *Fuji*, operated for the National Polar Research Institute.

Table 3: Gross Tonnage

Operator	<100	100-199	200-299	300-499	500-749	750-999	1000-1499	1500-1999	2000-2999	>3000
Meteorological Agency			1	3				2		
Maritime Safety Agency	1	1		2		1		1		
Fisheries Agency	1	1	3	3	1		2		1	
Metal Mining Agency								1		
University										
National			2	1	1		2			1
Private					1		1			
Industry				1						
Total	2	2	6	10	3	1	5	4	1	1

FOUR MONTHS, ONE WIFE AND THREE CHILDREN IN JAPAN

David Vere-Jones

It sometimes happens in New Zealand, where I live, that when a visitor is asked to give some impressions of his visit, remarks that were intended as helpful criticism are taken as an insult, and the poor visitor finds himself the centre of a storm of complaints, letters to the editor, and violent refutations. Part of the reason is that New Zealand, being a very new country and unsure of its place in the world, is very sensitive to comments from outside, eager for praise but upset by criticism. Japan, I am sure, is infinitely more civilized than New Zealand, but nonetheless I feel it is a slightly hazardous privilege to be asked to give one's impressions after a relatively brief visit. Japan is too complex, too different from a Western society, for one's impressions, even after four months, to be more than superficial at best, and at worst they may be wildly inaccurate. But I have found my visit too exciting and stimulating an experience, to be able to turn down such an invitation. I can only ask you to be tolerant of the inaccuracies and misjudgments I am sure you will find.

I would also like to stress that I see myself as a visiting scientist from New Zealand more than as a representative of Western science in some more general sense. The two are rather different things. With a few exceptions, as in agriculture, science in New Zealand is a modest affair, short in numbers and shorter still in cash. A New Zealand scientist, coming to Japan, is on a voyage of discovery. Despite the fact that Japan is now New Zealand's third largest trading partner (after the United Kingdom, the traditional market, and Australia, but ahead of the United States). Japan is still a very distant, exotic, unfamiliar country to most New Zealanders. Apart from the confrontation during the war, contacts have been minimal. In particular, few Japanese scientists have studied in New Zealand, few New Zealand scientists have visited Japan. In the future, however, the situation is likely to be very different. Japan's importance in the Pacific and its high reputation in science and technology are likely to draw increasing numbers of New Zealand scientists to Japan to study, to attend conferences, perhaps to initiate projects in areas of common interest, to see for themselves something of Japan, its people, and its way of life.

What impressions is such a visitor from New Zealand likely to form? Physically, he will quickly notice many similarities. Japan and New Zealand are both island countries lying between similar parallels of latitude, on the margins of the Pacific, if in opposite hemispheres. Like Japan, New Zealand has high mountains, forests, volcanoes, hot springs, earthquakes. In all those activities which stem from, and in turn generate, a love for the physical environment of a beautiful mountainous country—I mean such things as skiing, mountain climbing, hiking, seabathing, fishing—New Zealanders and Japanese will quickly find a common range of interests. New Zealand's climate, however, is distinctly milder than that of Japan, being warmer in winter and cooler in summer, vexed neither by Siberian snowstorms nor by Yellow Sea typhoons. On the other hand Wellington, my home town, takes a perverse pride in calling itself the windiest capital city in the World. For it lies right in the path of the westerly gales that earned those latitudes the title of the "roaring forties" in the days of the sailing ships, and, more than this, the wind is funnelled into Wellington by local hills and the configuration of the two main islands.

Ethnically, it is possible that there are remote links between the Maoris, the Polynesian settlers who were the first humans to reach New Zealand, perhaps a thousand years ago, and some elements at least of the early inhabitants of the Japan Islands. It is certainly striking that the Maori language, like Japanese, is basically syllabic, with similar vowel sounds and stress patterns. Maori words can be easily and accurately transcribed into kana (how different from English!) as for example the Maori names for New Zealand (Aotearoa, the long white cloud) and its highest mountain, Mt. Cook (Aorangi, the cloud piercer), which could be written アオテアロア and アオランギ respectively.

Of course the majority (nearly 90%) of New Zealand's present three million population is of British descent, the remainder being made up of Maoris together with smaller groups of Polynesian Islanders from the north of New

Zealand, Indians, Chinese, Dutch, Italians, Greeks and others. Indeed, until Britain's entry into the Common Market, there was a tendency for most New Zealanders to regard their country, rather sentimentally, as a part of "the old country" which had accidentally drifted into the wrong hemisphere. The Common Market episode, however, woke New Zealanders up with a jolt and made them realize that, sentiment or no sentiment, they would have to look to their neighbours in the Pacific, rather than to Europe and Great Britain, to sense the shape of the future.

Beyond such factual matters, which can in any case be pursued by looking up an atlas or such publications as the New Zealand Year Book, I hesitate to generalize. The best I can do is to record my own impressions, and hope that, however unrepresentative they may be, they may help to give some feeling for the likely reactions of New Zealand visitors to Japan.

My own impressions, then, fall roughly into two groups: some more technical, related to my scientific work; and some more general, stemming largely from our experiences as a family living together in a Japanese style apartment in the heart of Tokyo. I shall try to summarize these in turn, starting on the scientific side.

I am sure that no scientist coming to Japan can fail to be impressed by the high level of scholarship, the technical competence, and the dedication of scientists in Japan. Indeed these features seem to be quite characteristic of the Japanese scene. I have interests in both geophysics and mathematics; in neither field did I meet any scientist who could be written off as a man who talks impressively but has little real knowledge. It was more often I, than my Japanese counterpart, whose knowledge was superficial.

In geophysics, my main interest is in earthquake statistics, and in the development and use of statistical models for earthquake mechanism. In this field I was extremely impressed by the following features. Particularly striking, at least to a statistician, is the extent and high quality of observational data—clearly the results of a labour of love extending over several generations. The scale and high standard of current observational work is also extremely impressive, and to a New Zealander somewhat sobering. I guess that as much money is spent on seismological research in one university in Japan, as is spent on the same subject in all of New Zealand. Yet New Zealand is no smaller than Japan in size; its earthquakes are no less difficult to understand, and no less damaging; the best that can be said is that they are slightly less frequent, but in a sense this only makes the observational task more difficult. Here New Zealand's small population is a great disadvantage. With the best will in the world New Zealand could not afford to mount a seismological programme on the scale of the Japanese effort; yet no less may be required if a successful programme of earthquake prediction is ever to become a reality. Thoughts of this kind stressed, to me, the advantages to New Zealand of seeking closer and more regular scientific contacts with Japan. Although preliminary enquiries suggest that, once again, financial problems are likely to thwart such attempts in the immediate future, I know I share with other university colleagues who have visited Japan the hope that contacts will increase, and that visitors from both sides will become more frequent as time passes.

The only criticism I could perhaps offer in this field is that (as in New Zealand and the United States) the scale of effort and expenditure on the observational side is not yet balanced by a corresponding expenditure on the problems of data interpretation and analysis. Data, on micro earthquakes, on tilt, on level charges, on electrical, magnetic and gravitational field anomalies, is now accumulating at an enormous rate; but what is to be done with it? To my mind the answer must be, in part at least, in terms of developing appropriate statistical techniques and models. Actually, most geophysicists are adept at the task of data handling, and what is really missing is experience in developing models that not only fit the data in a descriptive way, in terms of histograms and the like, or in terms of a purely deterministic theory, but in some way that combines the statistical aspect with an adequate physical theory. I thought that Japanese seismologists were more receptive to suggestions of this kind than some of their Western colleagues, perhaps on account of their longer experience of working with good data. However there is still much scope for further work. The problem is a long-term one, calling for extended collaboration with statisticians and applied probabilists and the education of young scientists to take an interest in such a joint field.

In a very modest way—all that was possible in such a short trip—we were able to make some steps in this direction, using Japanese data, and to me this was perhaps the most rewarding aspect of my visit, scientifically

speaking. More than any official courtesy, I have appreciated the privilege of being able to talk to, to make plans with, and even to a small degree to direct, some of the very able young scientists I met in Tokyo. One feature that was especially memorable to me was the readiness of younger colleagues to listen to and follow up suggestions made in such discussions. Younger colleagues and even students in the West are not usually so courteous; give them a suggestion and more often than not they will deliberately choose to follow up some different point, just to prove their independence. Such behaviour can be time-wasting as well as disagreeable; it is the price we pay for encouraging individualism and originality too far. On the other hand, of course, too great an obedience to a supervisor's suggestions may inhibit the development of original ideas, and perhaps science in Japan, as a whole, may suffer somewhat from this tendency. However, I must hasten to add that I detected no lack of originality in my colleagues here.

Much the same comments on the quality of scientific work and the pleasure I have derived from individual contacts and working with younger colleagues could be made equally strongly on the mathematics side. In probability theory, my own field, the Japanese have established an enviable reputation, as witness, for example, the joint Japan-USSR Symposia on probability theory, where Japanese mathematicians contribute on equal terms with mathematicians from a country which has, for half a century or more, led the world in this field. Nothing that I saw suggested that this reputation was other than well deserved.

I cannot, however, let the mathematical side pass without some comment on what appears to me the difficult situation in which statistics finds itself in Japanese universities. Let me cite two circumstances which may illustrate what I have in mind. Very soon after I arrived in Japan, on my first visit to a Japanese university, I was disappointed to find that very little statistics was taught to students in the mathematics stream: some introductory material in the general science course in their first two years; some advanced options, mostly in pure probability theory but occasionally also in mathematical statistics, in the final year. I do not myself make a clear distinction between probability and statistics, but regard both as part of the overall attempt to provide a mathematical framework for handling the concept of "chance" or "randomness." This is surely a mathematical problem of exceptional importance in both practical and philosophical terms. To tackle it educationally, I believe the first requirement is a good mathematical background, followed by or associated with more specific instruction in statistical and probabilistic techniques. It is very important to capture able students' interests in these problems before they are diverted, as they surely will be if no intervention takes place, by the powerful attractions of pure mathematics. Hence it is important, in the undergraduate mathematics curriculum, to provide some stimulating and challenging probabilistic material (not just histograms and t-tests), at an early stage, and to back this up with a suitable range of more specialized courses later on. I am sceptical that this kind of programme can be successfully accomplished within an engineering or economics faculty, because it should be aimed at students with mathematical aptitude as their primary qualification.

The other circumstance I wish to quote is more particular. I have a special interest in stochastic point processes, a field with many important applications, that has been the subject of much recent work by mathematicians in Germany, the United States, the United Kingdom, the Union of Soviet Socialist Republics–even Australia and New Zealand. Sadly, I met only one Japanese mathematician who, in isolation and with considerable difficulty, had made this field his specialty. On the other hand I attended a conference on Markov processes, a main-line subject which has recently achieved remarkable heights of theoretical abstruseness, and was amazed by the size of the audience, which must have exceeded one hundred. No matter how excellent the papers (and they were indeed impressive, as far as I could tell), this contrast suggests to me an imbalance somewhere in the system. Perhaps, it results once again from a failure to give sufficient emphasis to applied subjects within the university programme for mathematicians.

I hardly know enough about the complexities of the Japanese universities to venture far into the diagnosis of this situation, even if it is accepted as undesirable. For what it is worth, my guess is that the Japanese university system retains a rather rigid distinction, along the lines of the old German educational system, between academic and technical subjects. The adequate teaching of probability and statistics, along with other applied mathematical disciplines, is frustrated by this division. Perhaps it is no accident that in Europe statistics has flourished to a greater extent in Britain, with its more pragmatic tradition, than it ever has in France or Germany. (With pure probability

theory, the situation is reversed; it blossomed in the bright intellectual atmosphere of France and later Russia, but never flourished in Britain's murky climate. Australia and New Zealand seem to be moving towards a compromise position, with strength in applied probability theory). In addition to this difficulty, the retention by the Japanese universities of the fixed departmental pattern of professor, dozent, and two assistants may hinder a flexible response to changing academic needs. Since the war, this pattern has been almost completely broken down in the English speaking universities, first by the creation of additional posts at the lectureship level (assistants), and more recently by the creation of multichair departments. Our own department in Wellington, which may be typical of smaller universities in the British Commonwealth, now has three professors, responsible respectively for pure mathematics, applied mathematics and statistics, and some twenty-one further staff members, at various levels of seniority, covering all three branches. While such large departments create their own problems, and no university has found the perfect answer to the statistics question, I believe such a departmental structure enhances the chance of developing a balanced undergraduate programme in mathematics and is able to respond relatively easily to the need to introduce new courses and eliminate older ones.

But enough of science and universities–dull stuff at the best when travel and contact with new cultures are the order of the day. What of our general impression of life in Japan?

During our first few weeks in Tokyo I went about in a state of permanent slight intoxication, not only on account of sake copiously supplied by welcoming hosts, but by a sense of excitement as I began to realize something of the unique environment that Japan offers. It is not merely that Japan is part of the mysterious orient, which is exciting enough for the Western visitor in any case; it is rather that Japan combines being the furthest East of the Far East with being the most Western of all Asian countries–and then adds to that mixture some notable peculiarities which are uniquely Japanese. On the one hand, all "mod. cons."* are laid on: I refer to such things as supermarkets, cornflakes, newspapers, rental cars, regular bus and train transport, bathrooms, toilets (even if of curious design–much to the amazement and delight of our vulgar children–are Japanese children so obsessed with toilet humor? I can't believe it; it must be another symptom of the degenerate West.) On the other hand there is no shortage of exotic features (to us)–street signs flash in mysterious ideograms; Japanese-style dress is still a common sight on women, and less frequently on men; small shops and temples flourish side by side with giant department stores and high rise buildings.

But it is not so much the visual aspect itself which is exciting, for indeed it is mainly drab, as the promise which it holds for exciting adventures of the mind and spirit. Here, I told myself, if anywhere is the place to penetrate the mysteries that divide East from West and to glimpse the synthesis the future may produce. And moreover–how very convenient–everybody speaks English. To penetrate these ancient mysteries all that seems necessary is to pose the question in plain English, and out will come the answer.

Needless to say, such euphoria cannot last; one can keep it going for a week or two but it can hardly be made to persist for four months, certainly with a wife and three children to bring one back to reality. Slowly, we became aware of certain difficulties. The first, the last, and the most deep rooted of all these is the language. From past experience I believed, and feel now more strongly than ever, that language is the key to a people. It is by understanding their language, and only by understanding their language, that one can begin to grasp how a foreign country lives and thinks. To understand Japan, it is no real assistance that one hundred and thirty million (or however many million it is) Japanese speak English; it may help the Japanese to understand us, but the reverse is not true. You cannot explain Japan adequately in English, for the words do not exist; you can only wait until we have learned enough Japanese to understand by ourselves. And how difficult a task this is. In early weeks I used to jokingly remark that there are three main reasons why it is hard for an English speaking person to learn Japanese. The first is that, in itself, Japanese is a complicated, idiosyncratic language, the thought pattern of which differs at almost every point from that of English. The second is that it uses Chinese characters to represent itself in written form,

*Modern conveniences: abbreviation used in house advertisements to imply the existence of Western-style plumbing facilities in bathroom and toilet.

and these cannot be learned quickly. The final and worst problem is that everyone speaks English, so that the brutal necessity of communicating in Japanese, the one painful stimulus which might perhaps have force to overcome the other hurdles, is politely removed. As time passed, and progress remained inordinately slow, this analysis seemed only too accurate, and the joke too painful to repeat.

So my dream, of viewing through Japanese eyes the fusion of East and West, is still unrealized, and it may be a long time before it comes much closer to reality. On the other hand, we became increasingly familiar with other, less romantic aspects of Japanese life. The great complexity of most administrative procedures, for example. Even to this day I am not sure that I fully grasp all the complexities of the regulations governing the advance purchase of a railway ticket, and this despite many educative hours queueing outside various wrong windows in the station. Perhaps it is for this reason that there is such a generally prevalent assumption that foreigners left to themselves will end up in a tangle, not an exaggeration, simply a statement of fact. Certainly this one did, with the result that I seemed to become increasingly dependent, rather than the other way round, on local assistance. But the cumulative effect of being forever dependent on outside assistance is very demoralizing. I suppose a cripple must feel the same way. I began to feel like Gulliver in Lilliput, tied down by a thousand tiny cords, each laughable in itself, but together quite sufficient to render movement impossible. After a while I longed to shake off the silken threads which kept me tied down to the role of "honourable foreign visitor" and to step into some humbler but more independent role. But this is both unrealistic and ungrateful; at the least, a necessary prerequisite for greater independence is greater understanding and a proper mastery of the language, and these are hardly capable of achievement in a four-month visit.

Other problems were associated with our desire for the children (aged 5, 8 and 9½) to attend a local Japanese school. Only in this case the problems fell on the shoulders of my long-suffering colleagues at the Institute, who had taken it on themselves to try and satisfy this equally unrealistic wish. For it is very difficult to find a Japanese school willing to accept totally strange, non-Japanese speaking, untested foreign children. There are good enough reasons, goodness knows, to avoid problems such an invasion might cause, and in this case common sense is well supported by regulations. All the more credit, then, not only to my colleagues for their efforts and perseverence, but for the school that, finally, hesitantly, accepted the awful responsibility of taking on our children–and then, with characteristic Japanese thoroughness, made an outstanding success of the venture. From our point of view the experiment could hardly have been more successful. Cheerfully the children set off for school each morning, bobbing along in yellow hats and blue uniforms; cheerfully they returned home in the afternoon. Exactly how the teachers, knowing only a little spoken English, managed to keep the children, knowing no Japanese, amused and interested is a mystery I shall never quite follow. It is true that the children invented a derogatory nickname–"Jabbernese"–for long periods of instruction in which familiar words were few and far between, but to my amazement they seemed to absorb little less than in their own schools in New Zealand. (What awful inferences this suggests concerning the effectiveness of teaching in New Zealand, or indeed in any country, I dare not contemplate.)

They did not make particularly rapid progress in learning Japanese itself; indeed they seemed interminably slow in taking the first steps. During the last month of our visit, however, it was clear that in some sense they had become attuned to the sound and pattern of everyday Japanese, were participating reasonably fully in the school programme, and were starting to acquire vocabulary at a rapid rate. They still spoke little but in real necessity could make good use of a small vocabulary, spoken without reference to grammar, but with excellent accents. Both the elder children learned to read and write kana fluently (without in general understanding the meaning) and knew a modest number of simple kanji. Both exhibited enthusiasm for copying out kanji, understood or not, and I realized very vividly, what had not struck me so clearly before, that the use of characters gives a whole new imaginative and artistic dimension to what with us is the painfully boring occupation of "writing."

More difficult for them, psychologically, than the language barrier was the need to change certain simple-sounding but deep-rooted behaviour patterns. Learning to bow to the teacher, for example. What a gulf in manners and social customs this little phrase encompasses. In New Zealand schools informality is carried to an extreme. This is not entirely an accidental feature; the myth of social equality is deeply rooted in the New Zealand way of life; every man is as good as his neighbour, if not better. This sentiment informs the advanced social

welfare legislation that has been a feature in New Zealand for the better part of a century. It also lies behind New Zealanders' fond (but, alas, erroneous) belief that they live in a happily integrated multiracial society. It is true that Maori and Pakeha,* professor and plumber, live on the same street, wear the same clothes, address each other by Christian names, dig their gardens at the weekend, and ask each other in for a beer at the end of it. It is offensive to the New Zealand spirit to suggest, by a bow or any other form or mark of outward respect, that one individual is socially, morally, or in any other way, superior to any other individual. But while this leads to a pleasant outward display of friendly informality, and to this extent may appear a civilized attitude, yet at heart it is a deception, for in fact social and racial differences are real and strongly felt, as they must be in any society. To the outsider, this New Zealand pretence at equality must seem faintly comical, but it is not a matter to be taken lightly inside New Zealand itself. Hence to ask a New Zealand child to bow to his teacher is not so light a matter as might at first be supposed.

Granted that such differences exist, add to these the difficulties caused by the language problem, and it is remarkable that the children took the change with so little sign of trauma, of "culture shock." Maybe the latter problem obscured the former; maybe children are naturally adaptable; but my belief is that there is a deeper reason. This is, that in both Japan and New Zealand, primary schools share one outstanding feature: in both countries the teachers are sincerely dedicated to the well-being of the children in their care, and relations between teachers and children are on a warm and friendly basis, bows or no bows.

Certainly I cannot speak too highly of the care and friendly attention bestowed on our children by their Japanese teachers, while on the other hand I cling to a loyal belief that pre-school and primary education in New Zealand are as good as anywhere in the English-speaking world. (In passing I would not claim the same for the secondary schools and universities.) At any rate, such a continuity at the human, emotional level makes their relatively easy adaptation easier to understand.

I would like to conclude by mentioning one final incident relating, appropriately enough, to our last day in Tokyo. For reasons both practical and sentimental, we had decided to have our last evening meal in Japan not in our apartment but at a Japanese style restaurant. The problem was to know which restaurant to choose. While we were walking, rather hesitantly in quest of a solution to this problem, we were overtaken by a car with waving children in the back seat—an occurrence infrequent enough in its own right. The waving children turned out to be schoolmates of Helen's and Andres's, also out with their parents on some family occasion. We had not met the parents before, but when they heard of our situation they insisted that we all be their guests at a joint family dinner in their favourite Japanese restaurant. And what a cheerful and delightful occasion this turned out to be, transforming a slightly melancholy ending into a joyful finale. Such spontaneous and generous hospitality is one of the finest features of the Japanese people in my experience. I refrain from citing even more striking examples for fear of embarrassing people who may read this article. Suffice it to know that they exist. We can hardly hope to repay such generosity in person, and at the best New Zealand hospitality (which, to be fair, is also noted) appears a casual and clumsy affair by comparison. But "the readiness is all," they say, and any Japanese visitor to New Zealand can be certain of a warm welcome in at least one home in Wellington.

Beyond this the future is obscure. My experience has convinced me that the mysteries of the East are not impenetrable, but it has also taught me that they cannot be penetrated easily, or quickly. I hope that I may have an opportunity to visit Japan again some time and pursue them further. And I hope that at least some of the Japanese who read this article will come to New Zealand and try the same experiment in reverse.

*European.

COMPUTER-AIDED DESIGN IN JAPAN'S SHIPBUILDING INDUSTRY

Richard F. Riesenfeld

There are seven major shipbuilders in Japan, namely Mitsubishi Heavy Industry (MHI), Mitsui Engineering and Shipbuilding, Nippon Kokan K.K. (NKK), Sumitomo Heavy Industry (SHI), Ishikawajima-Harima Heavy Industry (IHI), Hitachi Heavy Industry (HHI), and Kawasaki Heavy Industry (KHI). Through the very kind professional accommodations of Mr. Y. Hattori of NKK, who is the leading figure in the promotion of computer graphics and computing activity in the shipbuilding field in Japan, I was able to have visits with key personnel in the first five of the shipbuilders named above. Through Mr. Hattori's kind efforts, he planned an itinerary of many private briefings and presentations that would have been very difficult to arrange by myself. Mr. Hattori joined me at all of the meetings he had arranged. I was also accompanied by Mr. Koji Izumida, a former student of mine, who works under Mr. Hattori at NKK.

Although the Orient represents a formidable cultural barrier, I really develop exhuberance about my field when I visit Japan because computer-aided design is regarded as a very important activity to the economy. In Japan my work is well-known and there seems to be a feeling of gratitude toward people who spend their energy trying to contribute to this area of science. The Japanese are very interested in communicating, in learning new developments, and in demonstrating their impressive achievements in this area. The discussions never centered around whether to promote computer-aided design (CAD), only how to promote CAD.

On 26 December 1977 I met with Mr. Sumio Kohtake of IHI at the NKK headquarters in Tokyo. I received an extensive slide presentation of the operation at the Chita Shipyard, the most modern shipyard in the world. Through the maintenance of safety, IHI believes that it can find improvements in construction as well as reduced costs. The best way to achieve this is to use mechanization and to build standardized ships. The Chita Shipyard has a very modern layout that is designed to allow in-shop fitting of large block systems that are later carried to the dock to be pieced together to form a ship. The idea of the large block system is to decrease labor and improve working conditions by transferring the work to what traditionally was the preceding stage of production. The limitation on this kind of approach is basically the steel mill facility. Steel stock cannot be made any larger. In order to assemble these large blocks they use 350 ton Goliath cranes that they built themselves. To move the large blocks they use 200 ton trolleys in order to get the assemblies from the shop to the dock. In this approach, blocks, like the engine room or the pump room, are completely outfitted and then moved to the dock as a complete assembly, the largest weighing 680 tons requiring both cranes simultaneously.

Building the hull in this way as a block, they are able to minimize the scaffolding, which is a hazardous structure, and increase the construction work safety record. It is also easier to increase the mechanization within the shop environment. By manufacturing these large blocks in the shops, it is simpler to control the erection works, that is the scheduling, since only the large blocks have to be pieced together in the final stages. And finally, the quality is upgraded considerably by putting this construction in a shop environment.

In their schemes of shipbuilding they acid clean and paint the parts of the ship in the shop, rather than at the dock. This process is highly mechanized, leading to the elimination of dangerous and undesirable cleaning and painting chores after construction.

Again it was mentioned that the layout of the shipyard is critical, for transporting materials during construction is in fact a major cost of building a ship.

Some of the major arguments for mechanization and automation that were presented were that it is a very effective method of improving the working environment, that it is very helpful in stabilizing quality control at a high level, and that it increases productivity too. The labor unions seem to be in favor of automation because it leads to better working conditions and it is the only way to eliminate very undesirable jobs that may have to be performed

in unhealthy environments. Their automatic equipment included numerically controlled cutters, marking machines, bending presses using a thousand tons of force, very fast and accurate welding systems. NC* jigs, and a tower painter that travels around the ship. The most unique equipment that they showed in the slides was a block turnover rig that was designed for inverting large 200 ton blocks so that workers did not have to weld overhead or perform other tasks in uncomfortable or unsafe positions. This device looked like a large squirrel cage that accepted a block and rotated it 180 degrees so that it could be moved in the inverted position.

IHI's philosophy on software is "all starts and ends with design." Design sits in the center of a triangle whose vertices are material, production and scheduling. The design module generates information which is needed to activate the modules that take care of production control and material handling. The work force is well organized into small working groups which are autonomous in the labor division within each group. These are called multi-functional workers, and their experience indicates that these groups show increased productivity, which results in better worker morale.

The computerization of their operations not only include design but material control and production engineering. Their approach is highly integrated and really quite a top-down attack. Their computer system has a financial module as well.

Their hull design system is an example of their philosophy of computerization. Their system, which is good for all of their yards, aids them in every phase of the hull design from basic to detail to production. Utilizing this approach they feel that they have been able to increase accuracy and quality. Computerization and standardization go hand in hand in the way they approach shipbuilding. Standardization means that the workmanship becomes standardized, the code system becomes uniform and simple, and the design process becomes more standardized. They also use standardized computing figurations so that there is only one software effort within all of IHI, enabling each shipyard to use the same software. They can manage to do design in one office, then send out that kind of information to locations through communications links.

The representative of IHI said that graphics was one of their largest problems, particularly because graphics equipment has been very expensive in Japan. There are considerable tariffs placed on imported graphics systems. Also they feel that the imported data base systems they have acquired are not highly suited for interactive design interactive design work.

The next visit was on 27 December 1977 at the head office of MHI in Tokyo. MHI is a very diversified corporation whose name is familiar to people in many corners of the world. As a company their policy has been one of methodical adoption of new technology rather than one of marked innovation. They feel that this has been a prudent and profitable attitude toward computers, and it is an attitude which they hope to maintain in the future. Their record in bringing computers into the shipbuilding industry has been good, and there may be some recognizable sense in being second to implement the technology, thereby benefiting from the costly errors of their forerunners. Their company has 12 major sites in Japan, all of which have at least one computer. At the head office, the Nagasaki Shipyard, the Kobe Shipyard and the Hiroshima Shipyard, they have large or very large scale computers for both technical and business computing. These "four blocks" have been linked since 1971 in a telecommunications network. Just now they have been adopting the use of the so-called "J-1" lines which allow 312 to 552 KHz. Their aim in adapting these new high-speed lines is to reduce communications costs, unify their communications system, improve performance and liability, save on transmission line control functions, and to be flexibly adaptable for future growth.

MHI builds a great diversified line of ships including cargo ships, bulk carriers, LPG carriers, container carriers and ULCC's. They view their investment in computing as one that has paid off in allowing them to change their production quickly, at low cost, and with high quality. Their computing systems have helped them very much in optimal planning, and in labor saving approaches. Throughout it has helped them improve quality and accuracy in their products.

*"NC" denotes "Numerically controlled."

They use computers in a very extensive way in the design and production of ships. Their comprehensive system has simulation models which help them in the very beginning to understand the performance that certain specifications will lead to. They also are able to estimate the cost of a future ship and component costs like personnel costs with a special module in their system that supports these calculations. As in most shipbuilding systems another system is organized as a large collection of modules that orbit an integrated data base. Other systems exist for aiding the production of special kinds of ships like tanker ships or bulk carriers. It was not clear how integrated these special systems were. They also have some individual programs to perform some special kinds of analysis which seemed to be not integrated at all. Their programs for outfitting and piping seemed to be relatively advanced. The pipe program uses special languages to aid in the specification and in the graphical interaction. On the production end of the system they are able to drive an NC pipe bender from these specifications through these special languages. MHI is giving some attention to the use of computers on board ships to support navigation and record keeping on the ship after it is launched, but those directions are not in the primary scope of this survey.

Of the problems that MHI has encountered in connection with introducing computers into their shipbuilding business, they mention the personnel situation as the first one. Apparently the company has not developed an overall policy for helping people whose careers are adversely affected by use of computers. They recognize the need to establish a program of job rotation, retraining and education, and general counseling. Their network system has allowed them to communicate but they still feel that there is not enough compatibility and standardization among the various sites in order to fully benefit from the network possibilities. This has also hurt them in establishing a unified and centralized database, and it obviously has cost them in terms of efficiency. They now have a special team that is supposed to promote this kind of integration and standardization among the various sites on the network. The company is beginning to give some attention to the general area of data and program security, for that is an area that has been neglected so far. One interesting aspect of this study is that the information that people provide is largely subjective–there are very few measurement and evaluation schemes in operation. MHI would like to change that for their own case.

For the future they are concerned that the low profitability of shipbuilding in a depressed market may impinge on their program to improve their computer facilities and promote the degree of application of computers throughout their shipbuilding business. They argue the point that their business would be even less profitable without computers. In the future they are looking for other application areas for the CAD expertise which they feel have acquired. The microprocessor is an intriguing element to them, and they would like to find a wise way to introduce this device into their company. They also are striving for more integration between their technical and business computing and information systems. Their final goal is to make computers a utility for the people of the company, just as water or electric power is a utility now. But all of these aspirations require an upturn in the economic conditions for shipbuilding.

The afternoon of 27 December 1977 was spent visiting Mitsui Engineering and Shipbuilding Company. This company is generally regarded as the most innovative and resourceful among the shipbuilding firms in Japan, a position that the company holds largely because of the foresight and imagination of our host, Mr. Aya. Recognizing the depressed economics of shipbuilding in the early stages, this company underwent significant changes in their name from Mitsui Shipbuilding Company and placed Engineering in its name before Shipbuilding to relate to the public its objective of becoming a generally diversified engineering company. The expertise of this company has been used to diversify into markets ranging from marine systems to environmental systems to computer graphics. In all of these fronts they seem to be rather successful financially. For these reasons this company enjoys one of the most secure positions of all of the shipbuilding companies in Japan. In the company's headquarters we spent the afternoon talking about computers, computer graphics, and their uses in industry, and in particular shipbuilding.

The ROTA System which is implemented in their Chiba Shipyard is considered to be one of the advanced steps toward making shipbuilding an assembly line process. The general philosophy is to make ships on an automated assembly line. One of the outstanding features of this process is that it manufactures the egg-box components of a ship in an automated assembly line procedure. In order to achieve this they use automatic longitudinal positioning devices and automatic vertical fillet welding machines to set up the egg-boxes for the bottom of the

ship and to weld them in place. These components are then sent down the assembly line where they are rotated for convenient welding positions and set into position very precisely. They claim that the effect of this process is to substantially reduce their labor needs, improve the overall quality, and reduce production costs as they improve their working conditions and environment. The second outstanding feature of this highly automated shipyard is their computer controlled pipe processing shop called MAPS for Mitsui Automated Pipeshop System. Under this very advanced procedure the whole pipe shop is basically under computer control and programmable. The stock is fed to the assembly line where it is carried along and cut under NC control according to specifications. Then the flanges are fitted automatically and welded and finished under computer control. Then the pipes are sorted by machine and finally they are bent on an NC pipe bender also under computer control.

Mr. Aya is a very strong proponent of computer graphics and interactive systems. As was mentioned before, computer graphics equipment is very expensive to buy in Japan because the government places a high tax on imported equipment. Reacting to this situation Mr. Aya began a project within Mitsui to develop their own computer graphics processor and terminal. It is a limited color system that uses a beam penetration tube as a display device. Clearly they want to promote this peripheral to people who are interested in using it in their CAD applications. Their display called N11-B has very high resolution and features ease of interaction with the user. They are very proud of the "interactive wheels" or thumb wheels as we would call them, which control the cursor in the x and y directions. The N11-B system features a light pen, like almost every other system that I have seen in Japan. It is probably a result of the IBM indoctrination that the graphics people in Japan have a very strong affinity for light pens in preference over the data tablet. Although I have spent considerable time in discussions on this matter, I have not been able to convince even my most sympathetic Japanese friends that the data tablet approach is quite superior to the light pen in comfort to the user, accuracy in pointing, and ease in programming. There probably is not a sufficient opportunity for them to compare one against the other, since the light pen is so ubiquitous in Japan.

That evening we were guests of Mr. Aya at the Mitsui Club in Tokyo, a rare treat and an insight for a visitor into the gracious corporate living style that is accorded the high executives of this company.

The schedule for the 28th was spent at SHI visiting their programming facilities near the Oppama Shipyard and then the shipyard itself. This was about an hour and a half ride by train from Tokyo traveling westward around Tokyo Bay. During the remainder of the morning, Mr. Yoshio Mito briefed me on their computing operations at SHI. Their computing systems seemed to be quite similar in their functions to those that have been developed and used by the other shipbuilding firms in Japan. They were completely devoted to US systems, a decision which probably brought on some additional problems for them. For the general objective of providing an integrated interactive design database which is capable of supporting interactive computing activities, the choice of US systems presents some difficulty. One major problem is that support for computer graphics is expensive and awkward. A second serious problem is that the equipment, right from the hardware design and support, is not particularly well-suited to support interactive computing. Another problem for the shipbuilders and particularly for SHI is that they have adopted a database system which requires them to do the remainder of their programming in either COBOL or PL/1. Obviously the shipbuilders have generally chosen PL/1 when they found themselves in this situation, but that too presents difficulties. At any rate it is a system which was not developed for use in shipbuilding and is probably not the optimal database system to use for interactive design. And PL/1 is a very large, complicated and not especially fast running language to use for their systems development. However, PL/1 doubtless is a superior choice to FORTRAN, and it is a reasonably defensible choice in this situation. PL/1 is a powerful language and probably contains more than the shipbuilders need, rather than less.

After eating lunch on the premises we took a short bus ride to the Oppama Shipyard, which is located just next to the Datsun warehouse and testing grounds. Everything about the Oppama Shipyard is highly impressive. Two large Goliath cranes mark the site of the very modern shipyard located on this pretty Tokyo Bay. The visit began with a reception in the executive suite, and then after making acquaintances we moved to an adjoining movie room to view a film describing the shipyard. The movie, incidently, was done in color and with a very professional touch. Later when I inquired about its production, they explained that they had contracted out this movie to a promotional company.

As we began our bus/walking tour of this shipyard, an unusual characteristic was ubiquitous–this shipyard was very clean and inviting at every location that I had visited. We began at the place where the materials for the ship begin, their computer controlled stockyard. The materials arrive on a dock where it is unloaded from the delivery ships by large magnetic cranes. At this point the steel stock is examined automatically by a TV camera which is capable through its computer control of reading in the specifications and identification number for each arriving sheet. Then the material is automatically transported by computer operated conveyers and cranes to a designated position in the stockyard. Delivery of the steel plates from the stockyard to the fabrication ship is also carried out completely automatically.

Once the stock is brought from inventory to production use, it is automatically picked up and carried to a shop blasting room to remove rust and then it is automatically spray painted and passed along by a collocator, an electric flatcar, which deposits and stacks each steel sheet, which may measure 40 meters in length, at exactly the right place. As the sheet comes out of the automatic painting apparatus it is automatically reidentified. Since the computer has in its memory the correct identification of the part in the first place, it is simply painted on automatically once again on top of the new paint that the sheet just received.

Now the actual production begins. Large man-operated overhead magnetic cranes pick up the fresh stock that was neatly piled by the automatic collocator and deposited along a large area of steel webbed flooring in preparation for the cutting process. Then the NC plasma cutting machines partition the large steel formats or sheets into parts that are useful for making ships. This plasma cutting process is one of the most remarkable processes in the shipbuilding industry, for the results produce edges that clearly look machined rather than cut by heat methods. The cuts are accurate and very smooth, thereby reducing the welding costs significantly during the fabrication process. At this site they also have a 1500 ton press for bending the steel formats into various shapes that are needed to fit the hull and other parts.

At Oppama they use a special technique that allows them to join some pieces of steel by welds that are made on only one side of the sheet. I did not see this one-sided welding process in operation because it was very close to the national New Year holiday, but it seems like an idea that has considerable merit. There were some questions in my mind about the durability of these joints, but I did not get any information on that. The one-sided welding process saves them considerably in the fabrication process because it is expensive in space and time to turn over large, heavy steel constructs so that they can be welded on the underside. Overhead welding is a process fraught with dangers and faults.

Sumitomo is very proud of its egg-box assembling system. The egg-box construction is used in the deck and shell of oil tankers, and it has been a fabrication problem and an assembling problem for naval architects to find an economical solution. Their approach to this problem, like Mitsui's, is to fabricate the egg-box in the shop under a process that gives them more accurate control and one that can be done more automatically. The result is a component that costs them less in steel and in man-hours as compared with conventional methods.

In order to carry out the general strategy of manufacturing very large and heavy complete assemblies for the major components of the ship in the shop, it was necessary for them to develop a platform carrier to carry the assemblies from the shops to the construction site. For this purpose they have a 700 ton flatbed self-traveling carrier that can move these gigantic components. Some of these components are so heavy that they require both Goliath cranes working in unison to support and lower them into place.

The building dock is another innovative feature of this shipyard. It has dual entrances and three gates. One gate at either end and one movable gate that can be set at any of four intermediate positions between the two end gates. This arrangement gives them the capacity to build one and one half ships simultaneously. When the first ship is completed, it gets floated out through the exit on one end of the dock and the intermediate gate gets moved to allow enough room for the beginning of construction on the second ship. Then as the second ship is being completed, there is still room to begin construction on a third ship on the other side of the intermediate gate. Finally the second ship is floated out through the gate closest to it and by moving the intermediate gate between the one-third and two-third stations the process continues.

Having concluded a visit to the most modern shipyards in the Tokyo area, and one of the most modern in Japan, we headed for the train station to begin the rush hour ride back to my hotel in Tokyo.

The next day, 29 December, was spent with my host, Mr. Hattori, and my former student, Mr. Izumida, at NKK's Tsurumi Shipyard, Yokohama. During the morning I had the pleasure of meeting with the graphics and computer aided design group at NKK. They presented their current work on a graphics system and showed me some of their experiments with curve and surface design that had applications to hull form. Then we entered into a discussion of appropriate divisions of labor within an efficient distributed graphics system. Their aim was to adapt some of the principles that were published by Folley while he was at North Carolina and by Van Dan at Brown University. This discussion was interesting to me and I found that their approach led to rather flexible and convenient graphics systems from the point of view of the user. It did require however a fairly sophisticated amount of systems programming and development in order to attain their goals. Under the leadership of Mr. Izumida this group has managed to do some of the most advanced applications work using recent developments in curve and surface schemes that I have seen in any shipbuilding company. It will be very interesting to see what the eventual impact of this work is on the design and production process at NKK. Right now business is sufficiently depressed so that most of these studies are in fact rather academic.

After their presentation they asked me to show two of the films that I brought with me describing some of our own work at the University of Utah on the SURFED System. After that presentation there was some discussion of what we were doing and what our approaches were to various interactive problems. They also seemed to enjoy some of my discussion about the filming techniques which were used to produce the films, a reaction that should not have been surprising considering the popularity of photography in Japan.

For lunch we retreated to the NKK executive club located just a few minutes away from the shipyard. This very comfortable retreat was an excellent setting for some light conversation during lunch and then a working discussion period afterward. My marvelous host for this day and preceding week, Mr. Hattori, began the discussion with a review of the use of computer applications in Japanese shipbuilding industries, a review taken from a recent paper he had written. This was a very informative overview of the major developments in Japan over the last 15 years. Subsequently, the group asked me to describe some of my observations and findings during my travels, particularly from my European trip where they too knew many of the people and places I had visited.

Finally I was asked several particular questions about some of the literature in computer-aided design. Some of the papers I had cited were difficult for them to obtain in Japan so I told them that I would have copies posted to them upon my return. Their reaction of surprise was unexpected to me when I pulled out my portable dictating machine and read in a list of requests that they had for papers, and asked that they be sent off to them. Apparently the Japanese culture, in spite of their high level of development in electronics and communications, has not adopted the portable dictating machine as an integral part of their technological existence. So I spent about fifteen minutes describing how I use the dictating machine and what kind of support I get from the personnel around me.

At the conclusion of this pleasant afternoon in the executive club, Mr. Hattori gave a brief history of the Imperial Palace from the time that the emperor first moved to Tokyo for his home. By this point, in my stay this talk had real meaning to me because of the mornings I had spent getting up early and jogging around the Imperial Palace ground located just across our room in the Palace Hotel. We also got to know the surrounding area in Tokyo from many explorations on foot to Hibiya Park and other sites and stores surrounding the Imperial Palace.

Consistent with our grand style of hospitality, Mr. Hattori and Mr. Izumida drove me back to my hotel where we had a drink together and a final good-bye.

It was a very touching event to my wife and me to find some familiar faces emerging from a very dense crowd of holiday travelers at Haneda Airport during our time of departure the next day. My student and his wife as well as another acquaintance from Hitachi Software came to the airport to see us off as we left Japan. While the cultural gap between Japan and the United States seemed to be just as wide as the Pacific that we crossed, we departed with a genuine feeling of friendship for our kind and accommodating colleagues of Japan.

COMPUTER OPERATIONS AT TWO JAPANESE UNIVERSITIES

Anita P. Skelton

While temporarily detached from the Research Computation Center of the Naval Research Laboratory on personal business in Japan, I had the opportunity to visit the computer facilities at Hokkaido University and the University of Tokyo. At the latter institution, visitations were made at both the main campus at Hongō and at the auxiliary facilities at the Institute for Solid State Physics at Roppongi.

Professor Hariya of the Department of Geology and Mineralogy served as both my host and English translator during my visit to Hokkaido University at Sapporo. Admittedly there was some difficulty in discussing the facility in depth, due in part to the special computer terminology which is not typically part of the foreign language vocabulary of someone in another field. Given this constraint however, I still felt that a good deal of information was gained during the visitation.

This was my first visit to a Japanese laboratory of any sort, and I half expected to see computer printouts in kanji. What I actually found was a fairly similar setup, with about 90% of the work being done in FORTRAN (in English), and the only unique aspect of the printout being the accounting tail sheet itemized in yen.

The computer at Hokkaido University is a FACOM 230-75, a member of the "5" Series which was introduced in 1970. The 230-75 is a very large, byte-oriented single processor, which supports time-sharing communications. Its virtual memory disc-based operating system supports batch, remote-batch and real-time processing and multiprogramming. The line printers at the remote job entry stations (JRE's) are equipped with paper cutters and a conveyer belt apparatus which separates each individual's output automatically and presents the users' results in a very nice fashion. (Surprisingly, the central memory and central processing unit cabinets are trimmed in real wood; a touch of elegance that seemed to fit in with Japan's flair for making things pleasing to the eye.)

My second visit was hosted by Mr. Hiroyuki Oyanagi of Professor Minomura's laboratory at the Institute for Solid State Physics (ISSP), University of Tokyo. The ISSP houses a top-of-the-line FACOM 230-"8" Series Computer, the 230-48, which competes with the IBM 370/135 and 145. The 230-48 has semiconductor memory and the capability of accessing 4 bytes of data in .7 microseconds. It is capable of full scale, on-line multiprogramming via its large scale, general purpose, modular operating system, OSII/VS.

OSII/VS is a virtual storage operating system which allows each job to address 4 megabytes of virtual storage, and can handle 128 jobs simultaneously. Another feature is an integrated controller, which allows high speed mass storage peripherals to be attached via a Variable File Channel (VFCII). This variable channel signals all the control functions normally available in a device controller. A console color display unit with a 1000 character screen size is standard equipment.

After viewing the computer at the ISSP, we went to the main campus at Hongo where a beautiful building houses the largest university computing facility in Japan. The University of Tokyo has three HITAC 8800s and one HITAC 8700, all made by Hitachi, Ltd. These machines are super large scale, high speed modern computers which rank with the European ICL, CYBER 76, Honeywell MULTICS Series 60/Level 68, and IBM 370/158. Our guide indicated that the next upgrade would most likely be to an array processor.

The HITAC 8000 Series was designed to be compatible with IBM S/360 and 370 computers, and the 8800 is the largest of the series, with the 8700 being slightly smaller. The system provides batch, remote-batch, on-line, realtime and time sharing processing. The multiprocessing operating system controls the main memory unit, the

CPU, the I/O processor, and all I/O devices, ergo, every system component is flexibly controlled, thereby enhancing total throughput.

One of the more interesting features was the mode of operation: the first floor of the computer center provides a very attractive user interface. As the large sliding glass panels are automatically opened, one sees, on the periphery of the enormous room, a series of large glass enclosed cubicles which house all available peripherals, including high speed paper tape reader and punch, and magnetic tape units. In the large computer centers in the United States, the batch processing is generally operator controlled. RJE stations do permit the user to submit a card deck and retrieve output without an operator, but magnetic and paper tape units are usually in the operator's room. At the University of Tokyo, there are very few operators; virtually everything is handled by the user. (My host suggested that this may be a result of the high cost of labor in Japan.) The ubiquitous automatic paper cutter is another money saving device at RJE's, eliminating the usual wasted sheets of paper between jobs.

The facilities at Hongō are very up-to-date with many conveniences for the user. The keypunch room houses over 50 machines with keys in both English and the "katakana." A very comfortable and large user work space is provided. As I have discovered is typical in Japanese computer centers, the many unattended facilities are monitored by closed-circuit TV cameras. An underground storage area facilitated the housing of magnetic tapes, cards, etc., in a controlled environment, and users were provided with lockers. Another innovation was the Token Card System, which essentially provided the users with "credit cards" with their account number. When jobs are submitted they are processed according to their priority and then the output is held in the system. When a user is ready for output, the token card is inserted in a specially provided box, and the output is then spooled off the disc and sent to the line printer.

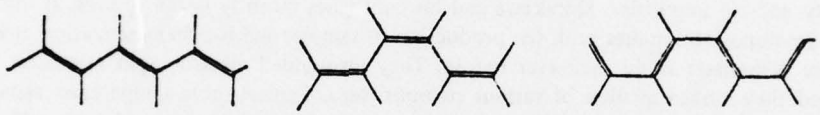
The University of Tokyo's HITAC system has about 20 RJE stations around the area and over 30 terminal lines; the communication lines are either 300 kilobaud, 2400 kb, or 4800 kb. Each of the seven regional university computing centers in Japan has a fairly large computer system of its own, with extensive use of terminals and RJE's. There are plans to link all of these systems to the Nippon Telephone and Telegraph (NTT) Network which is now predominantly used for on-line banking systems. My brief and spontaneous visit did not permit me to explore the exact status of this planned linkage.

Since I was in Japan for only a short time, an in-depth review of Japanese university computer operations was not possible; however, based on the little that I have seen, I feel that much can be gained from a closer association between East and West.

POLYACETYLENE, A GOOD ELECTRICAL CONDUCTOR

E. A. Kearsley

The catalytic polymerization of acetylene by metal alkyls and certain titanium compounds (Natta-Ziegler catalysis) has been known since 1958. In this process, the triply-bonded carbon pairs of the acetylene remain as doubly-bonded pairs in the polymer. Each link of the resulting polymer is then attached between bonds either on the same side of the link (the *cis* position) or on alternate sides of the link (the *trans* position). From these considerations, there are three isomeric forms of polyacetylene (plus, of course, combinations of these forms). These forms are illustrated in the figure.



Trans-transoid Cis-transoid Trans-cisoid

About 1970, at Tokyo Institute of Technology, Dr. Hideki Shirakawa working with Professor Sakuji Ikeda began a study of the physical and chemical properties of polyacetylene formed from Natta-Ziegler polymerization. One of the difficulties of studying this material was that it is virtually insoluble in anything. Normally the polymer is formed by diffusion of acetylene into a dilute solution of catalyst so that it appears as a powdery precipitate. This powder is extremely difficult to form into specimens convenient for physical properties studies. Shirakawa found that he could form films of the polymer directly on the surface of concentrated solutions of catalyst or on glass surfaces previously wetted with concentrated solutions of catalyst. (It is important to have a quiescent liquid surface and to exclude air during formation of the film.) Films formed in this way have a shiny metallic-appearing surface on the side which contacted the liquid during catalysis and a slightly more matte appearance on the gaseous phase side.

Shirakawa and Ikeda next developed methods of distinguishing the various isomeric forms. This was accomplished by calculation of infrared spectra (using factor group analysis) and comparisons with normal and deuterated polyacetylene samples. Ultimately, Raman scattering and electronic spectra also had to be employed to nail down certain subtle points. Using the ratio of the infrared absorption coefficients of bands occurring at $1015cm^{-1}$ and $750cm^{-1}$, they examined the ratio of *cis* to *trans* isomers in films formed under various conditions, particularly for different compositions and concentrations of catalyst solution and at different temperatures. They found that polymerization at -78°C with the most efficient catalyst system produced a film composed of 98% *cis* form, whereas, at 180°C a completely *trans* form of film was polymerized. Between these temperatures intermediate mixtures of the isomers occurred (for instance, at room temperature the *cis* content was about 60%). They also found that the *trans* isomer is the thermodynamically stable form at high (e.g., room) temperatures. The isomerization of *cis* to *trans* form proceeds at an extremely slow rate at room temperature, but at 180°C *cis* rich polymer formed at -78°C converts to virtually pure *trans* polymer in about an hour. During this isomerization (which is not reversible) the density of the material changes, passing through a distinct minimum when it is a 50-50 mixture of *cis* and *trans* forms. The exact mechanism of the isomerization and why it is irreversible is apparently still not clearly understood.

Although the polyacetylene films appear to the naked eye as dense impermeable films, a comparison of the density measurements (made by displacement weighings in carbon tetrachloride) and simple measurements of weight per unit volume (measured from the dimensions of cut samples) shows that the films are only about 50% solid material. This density was independent of the thickness of the film. Indeed, scanning electron micrographs of the films showed them to be mats of tangled fibers (fiber diameters of about 100 to 200Å). X-ray studies show that the fibers were of polycrystalline material with a diffraction pattern quite similar to that of coal (suggesting that it is composed of planar molecules packed parallel with a spacing of about 3.6 to 3.85Å). In fact, the differences between X-ray patterns for *cis* and *trans* forms of the material, while they are minor, do suggest a slight shift in lattice spacing (from 3.85Å for *cis* material to two spacings, 3.17 and 3.58Å for high *trans* content polymer). When the mats of fibers were stretched slightly, the Debye-Sherrer rings thickened on a diameter perpendicular to the direction of stretching. The inference from all this is that the fibers of the mats are composed of planar, so-called "extended-chain" crystallites, oriented parallel to the fiber axis.

Now, one of the interesting things about polyacetylene is that for an organic polymer, it has an unusually high electrical conductivity, presumably because it is a simple linear conjugated polymer. The electrical properties of the material have been of interest from the beginning and it was known that they depended strongly on the degree of crystallinity and on impurities. Shirakawa and his colleagues recently began to look at this property also. Because they had developed techniques both for production of samples and for characterization, it was possible for them to do a more systematic study than ever before. They also added electron spin resonance (ESR) to their arsenal of tools and they looked at films of various *cis/trans* ratio. Typical room temperature resistances of polyacetylene formed at various temperatures and with various catalyst compositions ranged from 10^4 to 10^8 Ωcm. In terms of conductivity at 0°C the finally quoted values were 4.4×10^{-5} and 1.7×10^{-9} Ω^{-1} cm^{-1} for *trans* and *cis* isomers respectively. But the most interesting thing is that both *cis* and *trans* polyacetylene acted like a semiconductor as far as temperature dependence of conductivity was concerned. (Measurement of actual conductivity is complicated by the fact that above 50°C *cis* form material isomerized into *trans* form material at a slow rate.) Well, the next idea is obvious. If a semiconductor, why not a conductor!

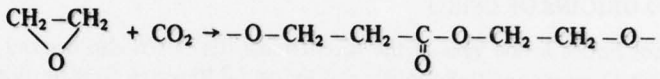
At this point in his research, Shirakawa went to the University of Pennsylvania to work with the well-known groups there led by Alan MacDiarmid and Alan Heeger. At that institution, exciting research is going on (supported by ONR) looking for novel conductors and even superconductors. The work there on single crystals of the organic metal tetra thiafulvalene-tetra cyanoquinodimethane (TTF-TCNQ) and on sulfur nitride polymers is widely followed. In a collaborative study while Shirakawa was at Pennsylvania, doped polyacetylene was shown to form a conducting polymer whose electrical conductivity could be systematically varied over a range of about eleven orders of magnitude. An insulator-to-metal transition was pinpointed, occurring at dopant concentrations of about 1%. By varying the dopant, both *p* and *n* type semiconductors could be made. The maximum conductivities at room temperature were comparable to those of single-crystals of TTF-TCNQ.

Of course, this discovery has generated much interest in examining electrical conductivity of polyacetylene derivatives, polyacetylene copolymers and polyacetylene with various dopants. Shirakawa, meanwhile, has returned to Tokyo Institute of Technology. While at Pennsylvania, he had noticed that there is a dramatic decrease in the transmission of infrared (in the range from 4000 to 400cm^{-1}) through polyacetylene films during the initial stages of the reaction with chlorine or bromine (during doping). Suspecting that there is something important going on here, Shirakawa is now using Raman scattering and electronic-spectra analysis to investigate. He tells me that he has strong evidence of a stable charge-transfer π complex formed during halogenation of either *cis* or *trans* polyacetylene. These intermediate complexes are IR absorbers responsible for the transmission loss.

Hideki Shirakawa is a research associate at the Research Laboratory of Resources Utilization (RLRU). Habitual readers of this Bulletin will recognize RLRU as one of the many research institutes supported by the Ministry of Education at national universities in Japan. (At the Tokyo Institute of Technology such institutes are customarily called laboratories to avoid confusion.) RLRU is not on the main campus of the Tokyo Institute of Technology but in a brand new building about an hour out of central Tokyo on the local electric train system (Denen Toshi line to Suzukakedai, actually in Yokohama). The Laboratory consists of 10 departments (bumon) each headed

by a full professor with an assistant professor, two research associates and a dozen or so graduate students. Hideki Shirakawa is a research associate in the High Polymer Department of Professor Sakuji Ikeda. Because he has just returned from Pennsylvania Shirakawa has only three graduate students in his program now but he expects his group to grow.

Other closely related work going on in the High Polymer Department of RLRU includes a study of Ziegler catalysts supported by solid surfaces (to get away from solvents) and a study of the use of CO_2 as a component of polymer systems. In this latter program, the following reaction is being studied



The result is a soft, transparent, glassy amorphous polymer.

AUSTRALIA'S COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

E. A. Kearsley

THE BACKGROUND AND ORIGINS OF CSIRO

You probably did not notice in the year of the Bicentennial that 1976 also marked the fiftieth anniversary (Silver Jubilee) of Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO). Rather than parading tall ships, however, Australia celebrated the occasion by appointing an Independent Inquiry charged with reporting on the role and function of CSIRO and with recommending for the future. The Inquiry published its final report (informally called the Birch Report in recognition of the chairman) near the end of 1977. As it happened, this was just before I visited Australia and the government scientists I met at that time were often in the process of reading and digesting that document. It was certainly a frequent topic of conversation, to a degree that surprised me. Later, I realized that, due to the peculiar circumstances of Australia, the recommendations for this one organization will have a tremendous impact on all of Australian science.

The similarities in attitudes and appearances between the United States and Australia are particularly striking on arriving in Sydney from Tokyo. Australians enjoy pointing out to us that it was the American Revolution and the resulting inaccessibility of Georgia as a penal colony which provoked the colonization of Australia. Probably more to the point is the post-World War II influx of immigrants, reminiscent of the "melting-pot" period in our history. Australia is very nearly the same size as the United States and has prodigious mineral resources and vast farmlands. Yet, it is surprising to find that the population is largely urban (over 85%). Judging by appearances, the standard of living is virtually indistinguishable from that of the United States. But, after these obvious similarities are noted, some important differences remain. The total population of Australia is about 14 million with an average density of less than 2 per km^2. (Compare 24 per km^2 in the United States or 289 per km^2 in Japan!) Most of this population is concentrated in a thin strip along the coast from Brisbane, more than half-way down the east coast, to Adelaide, only about a third of the way west on the south coast. As a result, Australia has one of the highest proportions of city dwellers in the world; 61% live in cities of 100,000 or more compared to only 48% in the United States. On the other hand, Australia is still relatively isolated. Overseas travel is expensive (as is internal travel) even in this age of cheap air fares.

Before World War II, Australia pretty much looked to Great Britain for leadership in culture and science. Although there were then six universities in Australia, graduate work in the sciences was generally done overseas. Several times during my visit it was pointed out to me that the first Ph.D. degree awarded in Australia was as recent as 1948. Since that time the universities have multiplied so that there are now at least 18 universities and several institutes of technology all offering graduate research programs in science. Still, with such a small population, the number of specialists in any field tends to be small and I have the impression that Australian academic scientists to some degree still look abroad for recognition.

CSIRO, in its early years (then called the Council for Scientific and Industrial Research) was almost totally dedicated to agriculture and forest product development. The National Standards Laboratory (Australia's counterpart to the National Bureau of Standards) was founded only as recently as 1936 along with an Aeronautical Laboratory and a Division of Industrial Chemistry. As might be expected, during the second world war CSIRO expanded further adding a Division of Radiophysics and a Lubricants and Bearings Section (later to become the Division of Tribophysics). After the war, all classified and military work was split off and the present name and character of the organization was set.

By the standards of commerce the Australian population of about 14 million is a small market and Australian manufactured products are seldom cheap enough to compete in the large international markets. (The economy is

focussed on agriculture and minerals.) Consequently, industrial laboratories in Australia are usually small and concerned with the details of technological problems. Large, strongly scientific, industrial laboratories a la Bell Labs or IBM just aren't found there. (See the previous *Scientific Bulletin*, Vol. 3, No. 2, for a report on AWA Research Laboratories, a miniature counterpart of Bell Labs.) As a result, the Federal Government directly conducts a major part of the scientific research done in Australia. CSIRO represents the main research effort of the government aside from the atomic energy laboratories and the military laboratories. Throughout Australia, CSIRO includes over 100 laboratories and field stations and over 7,000 people (of whom more than a third are scientists). This one organization constitutes a significant fraction of the total scientific research of Australia.

Because of these circumstances and the economic interests of Australia, it is not surprising that the activities of CSIRO are biased toward the problems of agriculture, wool and textiles and mining. A glance at the organization chart (Figure 1, taken from the 1976/77 Annual Report of CSIRO) will illustrate this point. Nevertheless, there is fundamental research going on at various laboratories of CSIRO over a wide range of fields of science. I had time for only a few visits to selected CSIRO laboratories during my recent trip to Australia and those visits were necessarily brief but sufficient to convince me of the quality and depth of the research to be found there.

NATIONAL MEASUREMENT LABORATORY

In Sydney I visited the National Measurement Laboratory which is a counterpart of my home institution in the United States, the National Bureau of Standards. (To be exact, it is a counterpart of that part of NBS engaged in metrological research.) On the day of my visit the laboratory had just passed the halfway mark in a move from its original home, a gothic sandstone building on the campus of the University of Sydney, Chippendale, to a modern new laboratory in suburban Bradfield Park. (My lecture was billed in the NML Newsletter as the "Last Colloquium at Chippendale.") My host, Dr. Russell Wylie, heads the Fluids Group that was still to be moved. His group of eight scientists works on physical properties of fluids (particularly thermodynamics and transport properties). Their permanent responsibilities include the maintenance of a standard scale of viscosity and the calibration of hygrometers. Viscometry in this group is presently confined to monitoring standard viscosity oils but there is a plan for the future to examine the wall-effect in the flow of gasses through capillaries. The hygrometer problem, however, has led to an extensive study of the molecular interaction of air and water as well as to measurements of thermodynamic properties of air-water mixtures. A standard wet-body (a wrapped wetted cylinder) has been developed and wind tunnel experiments conducted. To achieve good results, the surface wetting is done by flooding with triply distilled water (to avoid surface films) and experiments are conducted within minutes of wetting. Wet-body temperatures are monitored to 0.002°C. (The depression of temperature from the ambient will be about 7°C.) According to a simple theory, the temperature depression should be proportional to the difference in mole-fractions of water on the surface of the wet-body and in the airstream. The constant of proportionality, the psychrometric coefficient, must actually be corrected for a surface effect (elastic rebounding of molecules from the water surface) and a vapor pressure discontinuity created by the lack of thermodynamic equilibrium. Such corrections can amount to from 2% to 20% of the value of the psychrometric coefficient depending on the conditions of the measurement. This group uses a differential technique for a detailed study of these corrections. The temperature difference between two parallel standard wet-bodies in an air flow is plotted aginst the angle between the airstream and the plane of the wet-bodies. The resulting curve looks like a shallow sinusoid except that sharp dimples appear at the extrema of the curve caused by the "eclipsing" of one wet-body in the wake of the other. In the sample data I was shown, the dimples were about 28 mK in amplitude and could be directly related to the correction terms mentioned above. In the course of these studies, absolute values of the heat transfer coefficients of the wet-bodies were measured to within a standard deviation of 1.8%. At the Bradford site, a new wind tunnel will be available and some final details of this interesting work will be cleared up.

Tony Collins, a young Ph.D. (California Institute of Technology) interested in the statistical mechanics of fluids, has several projects going with the Fluids Group. With a special capillary viscometer developed earlier (Coor and Wylie) he is looking at the viscosity of binary liquids near their critical points. The viscometer is capable of a precision of one part in 10^5 in a viscosity range around one centipoise (decreasing to one part in 10^4 at higher viscosities). To avoid applying a vacuum to the test fluid a gravitational liquid head is applied on each run by turning

the viscometer end-for-end. Runs are made at different pressures and simultaneous electrical conductivity measurements are made. Collins is looking for anamolies at both the upper and lower critical points. He is also experimenting with precision torsional quartz crystal vibrators (50 KHz) as elements for viscometers. On the theoretical side, Collins is doing computer simulations of liquid structure by Monte Carlo methods and calculating transport properties.

In another project within the Fluids Group, very precise pressure-volume-temperature data is being generated for argon at high pressures. Dr. Ed Morris is the researcher in charge. Present work is confined to the range below five thousand atmospheres, but fourteen thousand atmospheres is a future goal. Presently, the pressures are generated by heating and expanding solid frozen argon. An important part of the system is a carborundum filter to remove aerosols (carborundum powder was highly recommended as a filtering medium which is effective without introducing new contaminants into the system). The pressure bomb was a steel cylinder lined with a silver bladder. Pressure measurements were made with a manganin gage (electrical resistance varies with pressure). An absolute pressure balance was used to calibrate as much of the range as practical and parabolic interpolation was used in the remaining range. I was gratified to hear that when the gage was used to determine the melting curve of mercury (temperature versus pressure), results were found to agree with those of NBS (Heydemann). Since argon is probably the most complicated gas whose equation of state one can hope to calculate absolutely by statistical mechanical methods, this careful and precise PVT data on argon is of great importance.

There was evidence that much thought had been given to the design of the new laboratories at Bradford. The planners had profited from studying the NBS move to its present laboratories at Gaithersburg, Maryland. Indeed, there were many details at the new NML laboratories familiar to me. A very large and impressive high voltage laboratory demonstrated the strong interest in high voltage research. Most groups were still unpacked and in no position to entertain visitors. However, they managed to show me a new laser device being developed. The device consisted, in essence, of a split beam laser and equipment for looking at the diffraction pattern after Bragg scattering. The pattern is strongly affected by the slight frequency shift associated with the scattering and appears to have great potential as a velocity meter. The group had rigged up a demonstration using the effect for a particle velocity microphone.

These limited observations do not begin to suggest the range of activities at the National Measurements Laboratories. Active research fields there include magnetic and dielectric properties, solid state physics, optics, acoustics, solar physics and molecular physics.

DIVISION OF TRIBOPHYSICS

The name of this Division has an interesting history. In 1939, when Australia faced the urgent problem of starting an aircraft industry from scratch, a Section of Lubricants and Bearings was begun within CSIRO to work out methods of manufacture and testing of aircraft engine bearings. It was this group which in 1946 was renamed Division of Tribophysics. The early work of the group soon involved them in fundamental considerations of the structure of metal crystals. For instance, an early problem of surface damage of thermally cycled bearings was traced to an anisotropy in the thermal expansion of a particular crystal form. Gradually, the emphasis of this Division focussed principally on questions of the behavior of crystals under stress, dislocations in crystals and the reactivity of surfaces of crystals and interfaces. Presently, technical interests range over metal corrosion, heterogeneous catalysis, ceramic refractories, properties of metals (particularly with respect to processes such as die-casting and extrusion) and materials tribology. Ancillary experimental techniques employed include low energy electron diffraction, Auger spectroscopy, scanning electron microscopy and field ion microscopy. The following is a random sampling of interesting developments from this laboratory.

(1) A method of identifying crystal imperfections was developed and demonstrated. Computed micrographs are compared with actual images of transmission electron microscopy. The method and applications are published in a book, *Computed Electron Micrographs and Defect Identifications*, A. K. Head, P. Humble, L. M. Clarebrough, A. J. Morton and C. T. Forward, Amsterdam: North Holland, 1973 and in a series of articles in Philosophical Magazine.

(2) The field ion microscope (FIM) allows the direct observation of the arrangement of atoms on a metal surface. It differs from the field emission microscope (FEM) in that FEM detects electrons tunneling out of a metal surface into high vacuum whereas FIM detects ions created by electrons from absorbed molecules tunneling into a metal surface. By combining the FIM with a time-of-flight spectrometer, the individual atoms from a selected area of a crystal surface can be analysed as they are evaporated. With this equipment (called an atom-probe FIM) the researchers identified inhomogenieties of the metal consisting of tiny particles of perhaps a few hundred atoms with an excess of one component of an alloy. The presence and distribution of these very small particles affect the overall strength and ductility of alloys.

(3) Thin coatings of nonoxidizing metals or intact oxide films can protect metals from further oxidation. The stresses induced in such layers by crystal structure changes across the interface and the elastic and plastic accommodation of these stresses are studied. Tungsten is a highly refractory metal but its oxide does not form a continuous film and thus does not protect from further oxidation at high temperatures. By low-energy electron diffraction and electron microscopy the early stages of oxidation of tungsten single crystals have been followed. The crystals of oxide nucleate on an ordered array of oxygen atoms absorbed on the tungsten surface. Needle-like oxide crystals grow in sets of directions depending on the epitaxial relationships.

(4) Zirconia is a ceramic material which has a phase change at about 1100°C. The mechanically destructive effects of this phase change can be alleviated by the addition of lime or magnesia. The improved thermo-mechanical properties of partially stabilized zirconia ceramics (PSZ) have been studied as a function of composition and processing variables. The advantages (taken from a Division Report) of PSZ specimens compared to conventional oxide ceramics are:

(i) A PSZ specimen, initially strong with a carefully polished surface, becomes even stronger when the surface is damaged by machining or abrading. In direct contrast, fine-grained strong conventional ceramic oxides with polished surfaces are weakened when the surface is damaged.

(ii) The strength of PSZ ceramics remaining after severe thermal shock is directly proportional to the original strength. Again, such behaviour is opposite to that of conventional oxides, the strength remaining after severe thermal shock being inversely proportional to the original strength, a fact which severely limits their engineering applications.

(iii) It is likely that strong PSZ ceramics display stable crack propagation during thermal shock, whereas strong conventional oxides show only kinetic crack propagation. This speculation is derived from the fact that the work of fracture of PSZ ceramics is directly proportional to the strength of the material. It is worth noting that at comparable strength levels of around 55,000 psi, the work of fracture of PSZ is about six times that of alumina.

A commercial process with patentable features is emerging from these studies.

(5) Zeolites are natural or synthetic aluminosilicates of sodium, potassium or calcium which form a three-dimensional cage-like crystal structure capable of trapping molecules of just the right size. (Zeolites are sometimes called molecular sieves.) At the Division of Tribophysics there is a strong interest in the use of zeolites as catalysts. Recently a zeolite catalyst was announced (Mobil Oil Corporation) which will convert straight chain hydrocarbons into aromatics, an important step in synthesizing gasoline from coal. The mechanism of this catalysis is not understood, but studies at the Tribophysics laboratory suggest that the particular large cell-size (20 X 20 X 13) of the structure is an important point. Nuclear magnetic resource studies are being conducted to observe the effects on different molecules trapped in the zeolite cells. An older method of forming aromatics, the Fischer-Tropsch reaction, utilizes a platinum catalyst. Studies at this laboratory have shown that traces of palladium in the platinum can extend its catalytic lifetime. The possibilities of forming platinum particles within zeolites (to control particle size) are also being examined.

This is only a sample of the many activities carried on under the banner of Tribophysics at this laboratory. My short visit left me with the impression of a group of producing, stimulated scientists generating rather fundamental

science, with a surprising amount of collaboration with Australian industry. Collaborative programs were cited in the areas of hard metals, tungsten carbide cutting tools, die casting, anti-corrosion paint, fiber-optics (see *AWA Research Laboratories* in the last ONR/Tokyo *Scientific Bulletin*, Vol. 3, No. 2), refactories and solid state electrolytes. The success of this laboratory is probably due to several factors, among others the location on the campus of University of Melbourne, the great interest of Australian industry in government laboratories and developments (their own laboratories are too small to compete in world-wide science), and, most of all, an enlightened management composed of producing scientists who understand what constitutes too strict control of programs. Whatever the reasons, this laboratory is conducting exactly the sort of program many others would like to achieve.

DIVISION OF CHEMICAL TECHNOLOGY

The research interests at this laboratory, in contrast to the last example, are somewhat narrower than its name suggests. Most of the science done here is aimed at problems of the utilization of wood or natural cellulose or, to a lesser extent, the problems of water purification. Dr. H. G. Higgins has a thorough program in what he calls chemothermomechanical pulping. He points out that, by manipulating the glass transition temperature of the lignin and by doing the processing in the neighborhood of that glass transition, simpler and more effective methods of manufacturing paper can be developed. This program is applying rather fundamental polymer science to suggesting possibilities for commercial processes. Dr. A. J. Michell has another program looking at the properties of composites formed from natural fibers and synthetic polyolefins. He has elucidated the properties of paper-polyethylene laminates (with an eye to building materials replacing wood and to packaging materials) and paper-ethylene vinyl acetate composites. Such questions as the effects of humidity on mechanical properties and the effects of various cross-linking procedures have been studied. Another program (de Yong) focusses on the mechanical properties of single fibers. The effects of humidity on the torsion and bending of fibers is the immediate topic.

A more technological group has designed a paper drying apparatus using a drying arm operated on the principle of a hovercraft. The device is said to allow the effective use of warm air normally rejected as waste and, thus, is a potential important energy saver. Paper drying is a principal consumer of energy in the energy-intensive paper industry. The group is currently looking for a commercial collaborator to exploit this invention.

Water is not plentiful in Australia and there is interest in water purification and management at this laboratory. Desalinization with heat-regenerated resins has many desirable features but it can not be economic unless extremely fine particles of resin are used. Yet, until now, handling of such micro-particles has not been practical. At this laboratory (in a collaboration with ICI Australia) a novel solution to the problem has been developed. Magnetic particles of polymer resin (already marketed as Sirotherm) are the answer. The magnetic forces between particles cause them to flocculate strongly but when agitated, they disperse and react rapidly, flocculating and settling out again very quickly when agitation stops. There are many other imaginative ways of using these materials, for instance, collecting oil spills.

Dr. D. E. Weiss, the chief of the Division of Chemical Technology, in his personal research, is concerned with novel methods of producing motor fuel from cellulosic materials. In particular he is examining the anaerobic production of volatile fatty acids by algae, algal harvesting and the separation of these fatty acids with low energy-cost.

THE BIRCH REPORT

I have already mentioned that the report of a government Inquiry of CSIRO has recently been published (Report of the Independent Inquiring into the Commonwealth Scientific and Industrial Research Organization, Australian Government Publishing Service, Canberra, 1977). This document, popularly called *The Birch Report* is an examination of the current state of CSIRO and a listing of 122 specific suggestions with a brief justification for each. There is much packed into the almost three hundred pages of the report and it is fascinating reading for a government scientist of any country. Some of the principal points are the following:

(1) The role of CSIRO should be "strategic mission-oriented research." By this the Inquiry means research aimed at the long-term benefit of Australian industry and the Australian community in general. But they caution

that they do not mean that CSIRO should concentrate on short-term technological problems. To quote from the Report;

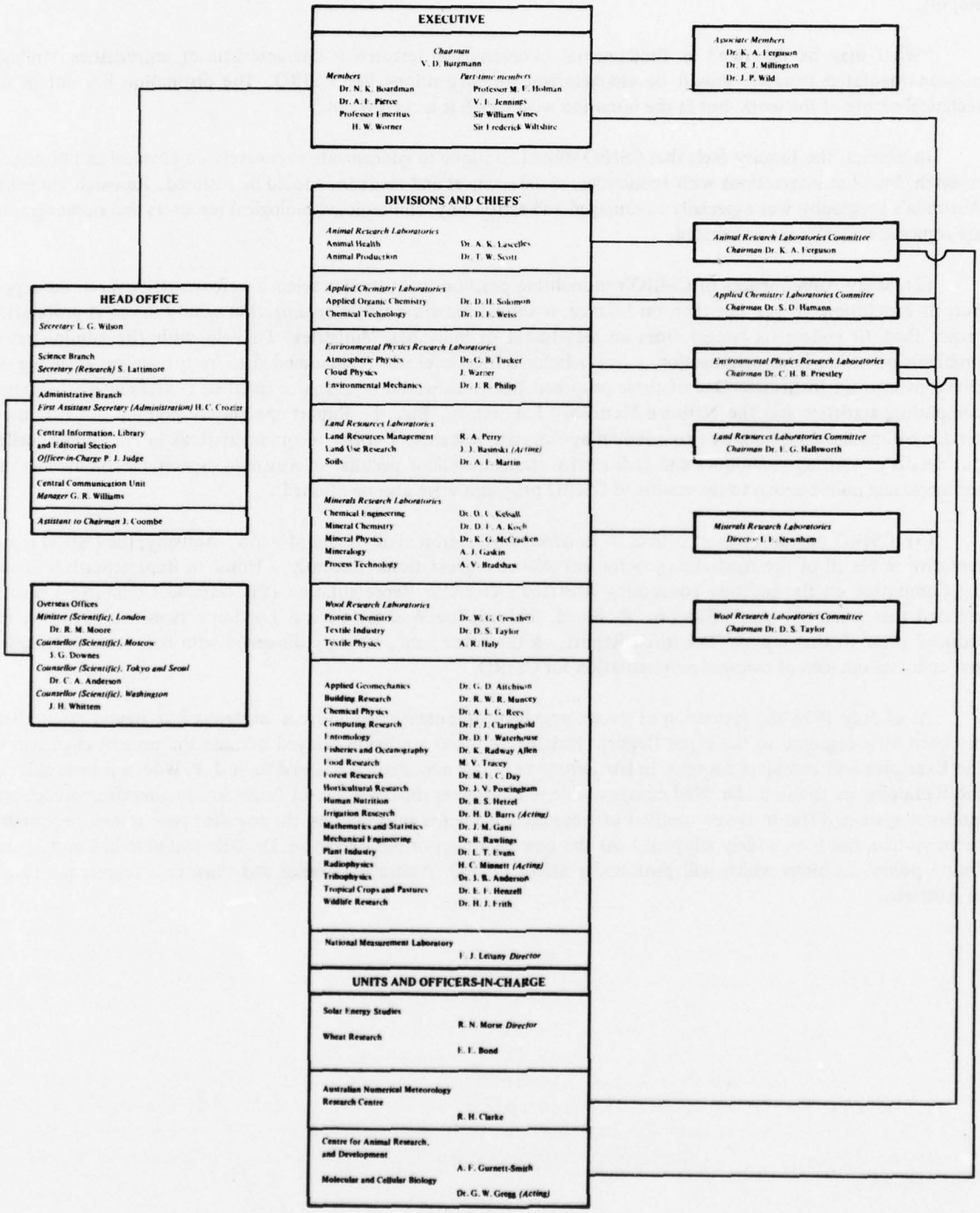
"What may be described as fundamental uncommitted research is characteristic of univerisities; strategic mission-orientated research should be characteristic of institutions like CSIRO. The distinction lies not in the technical nature of the work, but in the intention with which it is carried out."

In general, the Inquiry feels that CSIRO should continue to concentrate exclusively on physical and biological research, but that interactions with economics, social sciences and medicine should be fostered. Research unique to Australia's geography was especially encouraged and astronomy, climatology, biological resources and oceanography are topics specifically recommended.

(2) Many consequences of CSIRO's monolithic position in Australian science were worried over in the report but, in conclusion, it was felt that, on balance, it should remain a single organization with a direct appropriation rather than to collect its budget from an assortment of individual Ministries. To help with the administrative problems of such a large organization, a new administrative level was recommended to be formed by grouping the Divisions into six Institutes. One of these proposed Institutes would be a Service Institute containing mathematics, computing, statistics and the National Metrology Laboratory. But, the Report specifically pointed out that these service groups should be allowed to conduct appropriate research. Further recommendations in the Report spelled out details of staffing techniques and civil service status questions peculiar to Australia. Specific recommendations for increasing public access to the results of CSIRO programs were also mentioned.

(3) CSIRO operates liaison offices in London, Washington, Tokyo and Moscow. Actually, the CSIRO representative serves all of the Australian government science organizations. Recently, a House of Representatives Standing Committee on Expenditure concerning Australia's Overseas Representation (the Garland Committee) recommended that some of these offices be abolished. Indeed, the Washington and London offices had been severely reduced prior to that report. The Birch Report, on the other hand, strongly disagreed with that recommendation and endorses the idea of overseas representation for CSIRO.

As of July 1978 the formation of the six new Institutes mentioned above is underway but, beyond that, there has been little response to the Birch Report. Perhaps decisions are being delayed because the present chairman of the Executive will complete his term in late September. The new chairman is said to be J. P. Wild, a former chief of the Radiophysics Division. Dr. Wild enjoys a wide reputation as the developer of Interscan, an aircraft approach and guidance system. (The Interscan method of transmitting angular information, the so-called time reference scanning beam system, has been widely adopted.) As the new chairman of the Executive, Dr. Wild will be called on to guide future policy decisions which will profoundly affect CSIRO, Australian science and thus, to a degree, the future of Australia.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J. G. Downes
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Dr. C. A. Anderson
Counsellor (Scientific), Washington
J. H. Whittem
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Animal Production — Dr. T. W. Scott
Applied Chemistry Laboratories
Applied Organic Chemistry — Dr. D. H. Solomon
Chemical Technology — Dr. D. E. Weiss
Environmental Physics Research Laboratories
Atmospheric Physics — Dr. G. B. Tucker
Cloud Physics — J. Warner
Environmental Mechanics — Dr. J. R. Philip
Land Resources Laboratories
Land Resources Management — R. A. Perry
Land Use Research — J. J. Basinski (Acting)
Soils — Dr. A. E. Martin
Minerals Research Laboratories
Chemical Engineering — Dr. O. C. Kelvall
Mineral Chemistry — Dr. D. F. A. Koch
Mineral Physics — Dr. K. G. McCracken
Mineralogy — A. J. Gaskin
Process Technology — A. V. Bradshaw
Wool Research Laboratories
Protein Chemistry — Dr. W. G. Crewther
Textile Industry — Dr. D. S. Taylor
Textile Physics — A. R. Haly
Applied Geomechanics — Dr. G. D. Aitchison
Building Research — Dr. R. W. R. Muncey
Chemical Physics — Dr. A. L. G. Rees
Computing Research — Dr. P. J. Claringbold
Entomology — Dr. D. F. Waterhouse
Fisheries and Oceanography — Dr. K. Radway Allen
Food Research — M. V. Tracey
Forest Research — Dr. M. I. C. Day
Horticultural Research — Dr. J. V. Possingham
Human Nutrition — Dr. B. S. Hetzel
Irrigation Research — Dr. H. D. Barrs (Acting)
Mathematics and Statistics — Dr. J. M. Gani
Mechanical Engineering — Dr. B. Rawlings
Plant Industry — Dr. L. T. Evans
Radiophysics — H. C. Minnett (Acting)
Tribophysics — Dr. J. B. Anderson
Tropical Crops and Pastures — Dr. E. F. Henzell
Wildlife Research — Dr. H. J. Frith
National Measurement Laboratory
F. J. Lehany Director
UNITS AND OFFICERS-IN-CHARGE
Solar Energy Studies
R. N. Morse Director
Wheat Research
E. E. Bond
Australian Numerical Meteorology Research Centre
R. H. Clarke
Centre for Animal Research and Development
A. F. Gurnett-Smith
Molecular and Cellular Biology
Dr. G. W. Gregg (Acting)
Animal Research Laboratories Committee
Chairman Dr. K. A. Ferguson
Applied Chemistry Laboratories Committee
Chairman Dr. S. D. Hamann
Environmental Physics Research Laboratories
Chairman Dr. C. H. B. Priestley
Land Resources Laboratories Committee
Chairman Dr. I. G. Hallsworth
Minerals Research Laboratories
Director I. E. Newnham
Wool Research Laboratories Committee
Chairman Dr. D. S. Taylor

Figure 1

SOME GOVERNMENT AND ACADEMIC LABORATORIES OF THE REPUBLIC OF KOREA

E. A. Kearsley

My Japanese friends tell me that travelling to Seoul is something like returning to Tokyo at the height of the "economic miracle." Certainly the signs of economic expansion are obvious throughout the city. Enterprises flourish, high-rise office buildings and luxury tourist hotels are going up everywhere so that the skyline would be indistinguishable from a modern megalopolis anywhere in the world were it not for the characteristic rocky Korean hills ringing the city. Behind the modern edifices are narrow back alleys teeming with peddlers, carts and haggling customers which make for some interesting contrasts. But one immediately senses the tempering of all this activity by the knowledge that only a few kiolmeters away is the 39th parallel and all that that implies. This fact, the immediacy of a hostile force, and second, a national concentration on economic development are two factors which profoundly influence most things in South Korea.

In the middle of June 1978 I spent a brief week and a half visiting some representative government laboratories, scientific foundations and academic laboratories. I particularly looked for research on polymer physics and rheology but I found no comprehensive, coherent scientific program. There is some good work done in these fields, but it is usually isolated and motivated by technological problem-solving. In the field of polymers, chemical problems of production and handling are dominant.

For the visiting scientist in Korea it is hard to keep straight the proliferation of new and reorganized agencies. The government laboratories are commonly referred to by acronyms (KIST, KSRI, KAIS and so forth). Furthermore, because many laboratories are just forming or are changing direction there is much staffing activity. Scientists shift between laboratories with some frequency. To add to the confusion, it sometimes seems that all Koreans are named Kim unless they are named Ree, Rhee or Lee. Name cards don't always help much because, although they are used liberally as they are in Japan, they often do not have a romanized translation on the back. On the positive side, an increasing number of Korean scientists are returning home after education or work in the United States or Europe and their skill with English is a great boon to a linguistically unsophisticated liaison scientist.

Almost all government research organizations are grouped in one of two locations in Korea (except for the universities which are widely dispersed). The Seoul Science Park is in the Hongnung district of the city and includes Korea Institute of Science, Korea Development Institute, Agency for Defense Development, Korea Scientific and Technological Information Center and Korea Advanced Institute of Science. The Dae Duk Science City is near Daejon in the geographical center of the Republic of Korea, about two hours from Seoul by automobile or train. Eventually, Dae Duk will be an urban center in its own right but, for now, the city of Daejon (population about 400,000, approximately 45 minutes away) serves as the focus of the community. Many science organizations in Seoul are scheduled to move to Dae Duk. The Korea Standards Research Institute (the counterpart of the United States National Bureau of Standards), the Shipbuilding Industry Technical Service (complete with a model-towing tank) and the Korea Research Institute of Chemical Technology are already installed there. In the future, laboratories of oceanography, engineering, agriculture, petrochemicals, railroad, mining and fisheries will be located in Dae Duk. Chung Nam University will begin operations in the fall of 1978. By 1981 a popuiation of 50,000 is anticipated with housing, schools, shops, recreational and cultural facilities in a beautifully landscaped location among rolling hills.

The two science centers are a direct result of a government policy of dispersal of activities from central Seoul. Both centers are planned with lots of room for future expansion. A nice "spin-off" is the convenience of joint use of facilities, for instance, the technical library of KIST is one of the best in Korea and is open to use by the other

institutions of Seoul Science Park. The buildings housing the laboratories are new, spacious and well landscaped. Almost universally, the principal need of Korean laboratories at this time is equipment rather than buildings. Much of the staffing of the laboratories is done by attracting Korean scientists working overseas (commonly in the United States). There is a particularly strong demand for good Korean scientists with an advanced degree and several years of industrial experience. Special housing, sports facilities and the amenities of a pleasant life are located within the science parks (or are now being built) and these advantages help to attract a good staff. These attractions and a strong national pride among Koreans seem to result in an effective recruitment program.

According to statistics of the Ministry of Commerce and Industry (*Korean Times* of June 21, 1978) the investment of Korean industries in research and development amounts to only 0.3% of the gross national product. This number was compared with 2.6% for the United States and 1.7% for Japan. Such contrasts are perhaps the motivation for what seems to be Korean government policy: to stimulate and encourage industrial support of research and development. Also in the *Korean Times* was a series of articles on the decentralization of the university system. Other articles pointed out the shortage of skilled technicians and the draining of technological talent from the Ministry of Communications into private industry (*Korea Times* June 2, 1978). These problems have resulted in a strong university program to train more technicians (as well as pressures to raise salaries of technical government employees). In general, professors have heavy teaching loads and those who manage to do research are indeed dedicated scientists. Equipment is scarce but, as in many oriental countries, scholars are much honored and respected.

KOREAN INSTITUTE OF SCIENCE AND TECHNOLOGY (KIST)

The Korean Institute of Science and Technology is an autonomous nonprofit research organization doing contract research for government and industry. It was established in 1966 by the Korean government with aid from the United States. The 65-acre KIST compound is in the Seoul Science Park (about a half hour taxi ride from the central city). It has a staff of about 1,000 of whom half are professional scientists and engineers. The laboratories are organized by industrial technologies and include polymer engineering, chemical engineering, organic chemistry, applied chemistry, food and biotechnology, pilot plant, environmental engineering, materials science, mechanical engineering, metallurgy and metallurgical engineering. KIST often compares itself with United States institutions such as Stanford Research Institute or Battelle Memorial Institute. From 60 to 70 percent of the operating funds for KIST come from industrial contracts and the remainder from government contracts, but there is a recent concerted effort at KIST to reverse those percentages. The aim is to generate support for some continuing long-term program. I was asssured that collaborations or joint programs with United States institutions would be most welcome.

Dr. Nam Sok Choi, who is manager for polymer science and engineering research, arranged for me to meet the scientific staff in that field.

Dr. C. K. Yoon is a chemical engineer with a background in continuum mechanics. In 1971 he worked with Professor J. Ericksen of Johns Hopkins University on the continuum mechanics of liquid crystals. He has worked on technological problems of polymer fiber production and Freon production. For the future he hopes to generate some long-range programs from among the topics of high-temperature specialty polymers, high strength composites, anticorrosion materials and catalysis of synthetic gas into petro-chemical intermediates.

Dr. Sung Choi Kim came to KIST with a background in industrial science in the United States. He has worked on polyurethane adhesives and on flame retardant unsaturated polyesters. At KIST he has been attempting to find new uses for high-density polyethylene (in the range from 120,000 to 150,000 viscosity-average molecular weight). This material is anticipated to be overproduced in the near future. Kim has worked on the specifications, processing and testing necessary for utilizing this material in pipes for potable water. Currently he is developing methods of blending the resin with silicones to make pipes for handling hot water. A more ambitious project for the use of high density polyethylene is in the manufacture of synthetic paper. Kim envisions a "flash-spinning" process in which a 20% to 30% solution of HDPE in Freon is injected through a spinnerette into a chamber of low pressure and high temperature. In the process, the Freon evaporates to leave "fuzzy" fibers particularly suitable for the production of paper.

Among the scientists of this group were at least two more Kim's, two Jung's and a Yang. (Unfortunately, my notes did not contain better identification.) A Mr. Kim is a recent student of Professor Ree of KAIS. He is doing experimental and theoretical studies of the flow of suspensions using a model consisting of three components of the Ree-Eyring type. The two Jung's are chemists, one working in addition polymerization and the other in metallo-organic chemistry and the polymerization of silicones. The Mr. Yang that I met was also a recent graduate of KAIS who is engaged in a theoretical and experimental study of fiber spinning.

KOREA ADVANCED INSTITUTE OF SCIENCE (KAIS)

KAIS is a graduate school of science housed in a spacious building on a campus of Seoul Science Park. It began in 1973 (with U.S. Aid for International Development assistance) with 106 students and a faculty of 30 people and now, five years later, the first Ph.D's. are being graduated. The faculty has grown to 60 and the student body is now about 600. Such rapid growth is not unusual in Korea where graduate schools of science are a recent phenomenon but there are some unique circumstances. For one thing, it is an institution of the Ministry of Science and Technology rather than the Ministry of Education. For another, a special law exempts KAIS students from compulsory military service. (In exchange, the students are obligated to serve Korean industry or government for a minimum of three years.) The special housing and facilities of the Science Park are used to recruit particularly well-qualified faculty members from abroad. Degree programs are offered in applied chemistry, applied physics, biological science and engineering, chemical engineering, computer science, electrical engineering, industrial engineering, materials science and mechanical engineering. KAIS has a coordinating office set up at Stanford University for faculty recruitment, program development and research cooperation. A high percentage of the staff has had United States experience at universities and industries.

Professor Tai Kyue Ree is a well known professor emeritus from the University of Utah and also formerly of Kyoto University. The Ree-Eyring theories are widely known and used to describe plastic deformations of a broad class of materials. Currently, he is applying these ideas to plastic deformation of ceramics, metal alloys and single crystals. For polycrystalline materials the flow is decomposed into mechanisms due to dislocation motion and mechanisms due to grain boundary motion. The parameters of the resulting flow equation are self-diffusion activation enthalpies for the bulk material and for grain boundaries. The current state of the work appears in a series of papers (in English) in the Journal of the Korean Chemical Society.

Professor Ree also directs graduate students in a variety of projects including the following:

(a) Diffusion through membranes under pressure of a few thousand atmospheres is being studied. Hydrogels are synthesized, membranes formed and examined for the separation of blood plasma, urea and other such medical applications.

(b) The rheology of clay suspensions and other thixotropic suspensions is being studied with Brookfield and Couette viscometers (see Kim of KIST). The Ree-Eyring ideas for application of reaction kinetics are used in the analysis.

(c) A theoretical chemical study of diffusion through membranes postulates that there are three states of water (each with a different structure) within the membrane.

Professor Iwhan Cho is a former student of C. G. Overberger of the University of Michigan and at one time worked for Uniroyal Research Laboratories. At KAIS he is synthesizing block copolymers. He is looking at such combinations as hydrophyllic-hydrophobic and stiff-flexible diblocks. He also synthesizes multiple-block copolymers in various arrangements (ABA, BAB, etc.).

Associate Professor Woong Kil Choo is formerly from Massachusetts Institute of Technology. He has a current project in the Materials Science Department on the creep of nickel-copper alloys. The large testing laboratory he showed me was roomy, but still sparcely equipped. In another laboratory an old electron-microscope sat, broken

down. Repair would be too expensive and a replacement is being sought. Choo tells me that he plans to start some activity in piezo-electric ceramics and possibly also in PVF_2, the piezo-electric polymer.

Professor Sang Soo Lee was formerly the first president of KAIS. He is presently the Vice-President of the Korean Physical Society and Director of the Optics Laboratory at KAIS. Lee exhudes enthusiasm and energetically trotted me through a succession of active (but poorly equipped) projects:

(a) A project in the design and construction of multilayer optical beam-splitters is underway.

(b) The possibilities of developing a high power laser using argon fired by an electrical discharge are being examined.

(c) A two wire exploding-wire system is being studied with a mechanical light chopper and an oscilloscope. The wires can be exploded in series or in parallel. (Symptomatic of the equipment problem at KAIS, the present limitation on this project is the speed of the oscilloscope.)

(d) A CO_2 laser (in the infrared) will be transversly excited and will give 50 nanosecond pulses. This will be a very high-power laser by Korean standards.

(e) Korea currently receives satellite pictures of the Korean peninsula from the United States. Lee has several ideas for methods of employing lasers and transparencies of these pictures to extract data. He proposes to monitor the atmospheric background, for instance, and thus to detect atmospheric pollution.

(f) Hangul is an alphabetic form of writing Korean characters, developed by the enlightened King Sejong in 1446 and now almost universally used. In practice the letters of this alphabet are grouped together in standard ways to form syllables. Professor Lee has taken advantage of the fact that each of these letters can be formed by combining short strokes from among seven possibilities. (Actually eight strokes would be required except that Lee adopted a delta-like shape formed from three strokes to replace a circular stroke.) With the use of a mask and a holographic technique it is possible to locate all occurrences of a given stroke in a page of print. Thus, with seven operations, Lee optically "reads" a page of print. Since the process is so well suited to Hangul, Lee suggests with a grin that old King Sejong may have foreseen the invention of lasers.

KOREA RESEARCH INSTITUTE OF CHEMICAL TECHNOLOGY (KRICT)

Korean industries, big and little, are projected to need greater sophistication and wider research and development efforts for the 1980's. The Korea Research Institute of Chemical Technology is a response to this need. It is to be a central research and development facility located in Dae Duk Science City and available to all Korean industry on a contract basis. It is a private institution, financed by subscription from the chemical industry, but encouraged by the government which guarantees the initial building loans. Companies will use KRICT in several ways: by contracting for research on their own (possibly proprietary) problems by KRICT personnel, by using KRICT consultant services, by arranging for their own personnel to use the equipment of KRICT, by using KRICT for the training of personnel or merely by using the KRICT chemical information center. Several chemical companies already have plans to build private laboratories as satellites within the KRICT complex.

Dr. Chwa-Kyung Sung, President of KRICT, has been described to me as the most knowledgeable person in the polymer field in Korea. He is a past president of the Korean Chemical Society and a former professor of Seoul National University. I had arranged to visit KRICT when I met Dr. Sung at a Polymer Society meeting in Japan but at the time of my visit he was away on an emergency. Vice-president Tae Hyun Lee showed me the Institute.

KRICT is just beginning and only 96 people had been hired of the 135 authorized for this year. The staff was still largely administrative because the laboratories were not yet functioning. Initially, five technical groups are planned in the fields of fine chemicals, inorganics, high polymers, pollution and chemical engineering. Each group is

to be set up and directed by an experienced scientist who will staff his group largely with chemistry graduates, young Ph.D.'s and technicians. Dr. Suh Bong Rhee of the Polymer Processing Laboratory is presumably typical of these group leaders. Dr. Rhee has a Ph.D. (1971) from the University of Cincinnati and has had many years of industrial experience in Canada (building materials research) and in New York (statistics). He plans to develop uses for plastics and plastic foams as construction materials and as building insulation.

Since virtually no equipment had yet been delivered, there is little I can report on the laboratories other than that the buildings seemed excellent and the staff enthusiastic. The shop was already active (making street lamps for the complex, an unplanned boost to the building budget). The chemistry laboratories were empty, paper tape indicating where benches and piping would be installed. A large three story area had been designated for pilot plants. An airy pleasant library was still without stacks.

Outdoors, sites were being levelled for satellite company-laboratories around a small pond. I was told that six company laboratories (plastics, cement, textiles) are already building or planned. It is not hard to imagine a bustling research center by 1981 when the staff of KRICT is projected to reach 300.

KOREA STANDARDS RESEARCH INSTITUTE (KSRI)

This institution is at Dae Duk Science City. At the time of my visit the finishing touches were still in progress on the main building and of 300 pieces of technical equipment on order less than a third had been delivered. Dr. Nak Sam Chung, the electronics expert responsible for setting up the Korean time standard, told me that a transfer clock from the U.S. Naval Observatory was due to arrive in late August and that he was concerned with the preparations. Other scientists also were primarily engaged in planning and ordering equipment.

KSRI is a Korean counterpart of the United States National Bureau of Standards. NBS advised in the planning of KSRI and is an honorary member of the Board of Trustees (as is AID, which supported the foundation of KSRI with a loan). NBS continues to advise on problems of equipment and metrology. Over 20 of the present staff of KSRI have visited NBS for orientation and for training and this program of visits will continue. (A more detailed report on KSRI appeared in the previous ONR Tokyo *Scientific Bulletin*, Volume 3, No. 2.)

HAN YANG UNIVERSITY

Overall, Seoul National University is undoubtedly the most prestigious in Korea but Han Yang University is highly esteemed among the private universities. Its College of Engineering in particular is considered to be the best. Professor Kyu Suck Choi of the Department of Industrial Engineering was my host for a visit. Choi is a graduate in chemistry from Seoul National University and currently does research on the synthesis of chelates for extracting metal ions from solution. His most recent work is with $-NH-CS-NH_2-$ groups which selectively absorb mercury. Choi tells me that about one out of five faculty members manages to do regular research in spite of heavy lecturing schedules. Dr. Wan-Taik Kim does research on chopped-glass fiber reinforced thermoplastics (polypropylene and polyethylene). He uses impact studies and tensile testing. Dr. Kea-Young Kim is a polymer chemist with a degree from the Tokyo Institute of Technology who works with permeable membranes. A third Kim, Dr. Jin-Il Kim is interested in catalysis. At the time I visited he was about to leave to spend two years at the University of Delaware. The Department of Chemical Technology was formerly the Department of Polymer Science and Technology and an active interest in polymers remains.

The Department of Material Engineering is a center for research on metals. Professor In-Hyng Moon is a graduate of the University of Münster (Dr. rer. Nat.) and has done research at the Max Planck Institute in Stuttgart. He had several projects underway: a study of sintering of tungsten, extrusion and diffusion in aluminum and general work on powder metallurgy. A younger researcher, Dr. Ji-Ho Song, had just returned from the University of Osaka where he had worked with Professor Kikukawa on fatiguing of steel. Dr. Song had some interest in extending his fatiguing studies to plastics. Myung Soon Kang is a dean and one of the most senior professors of engineering. His specialty is the study of metal cutting and he does theoretical and experimental studies using a fully instrumented lathe.

INHA UNIVERSITY

Inha University is about an hour out of central Seoul, actually in Inchon which is the port for Seoul. It started 24 years ago as a small technological school but it has recently grown to be one of the principal technical universities of Korea. Ten years ago Dr. Choong-Hoon Cho, president of Korean Airlines, accepted the chairmanship of the board of trustees and initiated a vigorous development program. Several airplanes mounted as "sculptures" around the campus remind one of this association. Recently, the Korean government has increased the student body at Inha as a part of the program to decentralize from Seoul.

Professor Ichsam Noh introduced me to the Department of Polymer Science and Technology. Noh is a graduate of Seoul National University and has done post-doctoral research at the University of Wisconsin. He is currently looking at graft polymerization induced by corona discharge, particularly with polypropylene films and fibers. Professor Noh had published extensively from the National Industrial Research Institute before coming to Inha, but he tells me that the typical lecture load of nine hours per week has cut down on his publication rate and he now manages only about one paper per year. Other professors in this department also carry heavy teaching loads and are active researchers. Professor Ki Hyun Chung has a background in polymer synthesis. He is working on problems of utilizing a tactic polypropylene for a building material (currently it is a waste product used only for fuel). Associate Professor Dong Choo Lee is the youngest of the faculty of this department. He had just returned from Osaka University where he had worked with an ultracenterfuge with Professor Hiroshi Fujita. His research is on the synthesis of polypeptides and the solution properties of copolymers. Currently he is looking at a copolymer of a rod like structure with a flexible chain. The fourth faculty member of this department, Associate Professor Chung Yup Kim, is visiting the University of Wisconsin for two years. He is a physical chemist who works on surface properties and the strength of materials. Currently he is interested in the effects of corona discharges on polymer surfaces.

Professor Noh told me that when the Polymer Science and Technology Department was started in 1970 there were five such departments around Korea. Presently, Inha University has the only polymer department remaining. The undergraduate program they offer is for students who have completed the two-year Basic Engineering program. They then devote their junior and senior years to basic polymer science, polymer technology, chemistry (thermodynamics and unit operations) and various seminars. The aim of the program is to produce engineers for polymer-related industries in Korea. Presently the department has enrolled about 40 undergraduates and seven graduates. (Overall, Inha has about 6,000 undergraduates and 160 graduate students. It produces Ph.D.'s at a rate of two or three per year.)

CONFERENCE REPORT ON THE INTERNATIONAL UNION OF THEORETICAL AND APPLIED MECHANICS (IUTAM) SYMPOSIUM: HIGH VELOCITY DEFORMATION OF SOLIDS

E. H. Lee

INTRODUCTION

The Symposium was held at the Science Council of Japan in Tokyo, August 24-27, 1977. The Scientific Committee was chaired by Professor S. Fukui and was under the secretaryship of Professor K. Kowata of the Institute of Space and Aeronautical Sciences, University of Tokyo. The Organizing Committee was chaired by Professor Fukui, with Professor Kowata as Vice Chairman and Professor J. Shiori, Department of Aeronautics, Faculty of Engineering of the University of Tokyo, as Secretary.

IUTAM symposia are planned to involve a restricted number of participants so that interactive discussion from the floor is facilitated. To this end, engineers and scientists who are active researchers in fields relevant to the topic of the symposium are invited. Some eighty researchers participated in the symposium under discussion. The largest delegation, numbering approximately sixty, represented the host country. Some fifteen attended from the United States, with one or two delegates each from France, Poland, Saudi Arabia, Sweden and the United Kingdom. Although several contributors from the USSR were listed on the program, unfortunately they did not attend. The limited number of participants and the selection of contributors generated informed and discerning discussion.

The early development of the theory of plasticity and its application to technological problems were in the main based on the classical ideal elastic-plastic or plastic-rigid theories. These provided useful information on, for example, the stress and deformation analyses of steel structures and of some metal forming processes. The latter were mainly limited to deformation in plane strain using slipline field theory based on a perfectly-plastic-rigid model. Some aspects of the predicted stress and deformation fields were corroborated by experiment, for example, the extent of the plastic regions in plane strain solutions exhibited by an etching technique which exposes the modification in metallurgical structure caused by plastic flow [1].* However, as the theory progressed and related experimental measurements were carried out with increasing precision, it became evident that more accurate models of constitutive relations (often termed stress-strain laws) were required to adequately express material response. Such models incorporated strain-hardening and the unsymmetrical Bauschinger effect. The classical laws of plasticity are incremental in nature, but are not rate dependent, since derivatives of stress and strain with respect to time occur linearly on each side of the constitutive equations so that a change of the time scale does not affect the path transversed in stress-strain space. It was found that as strain rates or rates of loading increased, rate effects did begin to exert a significant influence on the constitutive relations. Thus the classical laws of plasticity had to be modified for high velocity deformation, and new models were proposed which incorporated rate effects. These were often motivated by crystallographic or atomic mechanisms of deformation.

This knowledge of the response to load application of metals in plastic flow and of the development of constitutive relations to express this response in mathematical form set the stage for the Symposium and determined the structure of the program. Although the largest group of papers, eleven in number, were concerned with the investigation of technological problems involving rapid deformation, the next largest group, seven in number, was concerned with microscopic mechanisms of deformation and the associated macroscopic laws. Five papers were concerned with the direct measurement of macroscopic laws or their formulation from the corresponding analysis of the response. The analysis of dynamic deformation in wave propagation was discussed in five papers, and the rest formed smaller groupings associated with the measurement of deformation characteristics and fracture properties. The papers will be discussed in these groupings, so that the development of various aspects of the subject can be most easily assessed.

*Numbers in square brackets refer to the reference list at the end of the report.

MICROSCOPIC AND CRYSTALLOGRAPHIC MECHANISMS OF DEFORMATION

U. S. Lindholm of the Southwest Research Institute, Texas, discussed the various mechanisms controlling the motion of dislocations in the high velocity regime. This was carried out by utilizing deformation maps, as introduced by Ashby, of plots in stress-temperature space to delineate regions in which athermal, thermally activated and viscous drag type stress-controlled mechanisms dominate the generation of plastic flow. Measurements on aluminum and copper showed that thermally activated mechanisms at lower strain-rates were replaced by viscous drag controlled dislocation motion in the high strain-rate range (10^4-10^7 sec.$^{-1}$), and specific characteristics were presented. An analogous study was carried out by J. Shiori, K. Satoh of Tokyo University and K. Nishimura of the Nippon Steel Corporation of the strain-rate influence on the flow stress of OFHC copper in the strain-rate ranges 30-100/sec. and $>10^3$/sec. The results were also interpreted in terms of dislocation dynamics. The lower range measurements utilized ultrasonic attenuation and velocity studies while those in the higher range were based on split Hopkinson bar measurements. The interpretation of the former range was in terms of long range and localized obstacles to dislocation motion, and for the higher strain rates by separating the contribution of intrinsic drag from thermally assisted processes.

R. J. Clifton of Brown University described an ingeneous design of a single crystal of LiF target plate and a thin flyer plate which generated a single square loading pulse of short duration. This was achieved by impedance matching to eliminate repeated impacts, a longitudinal momentum trap at the rear surface of the target crystal to eliminate reflected longitudinal waves and the use of a star-shaped flier plate to reflect unloading waves from the free lateral boundaries away from the central octagonal test region of the crystal. Etch pit patterns showed regions of intense plastic deformation near both the front and rear surfaces of the target crystal, corresponding to supersonic dislocation velocities if plastic deformation were considered to be restricted to the duration of the pulse. Only short glide bands were indicated near the center of the crystal plate. These results indicate the need for improved understanding of the role of free surfaces in the generation and multiplication of dislocations.

A. T. Yokobori, T. Kawasaki and T. Yokobori of Tohoku University, Sendai, related the dislocation generation emitted by a source with the properties of the upper yield stress in mild steel. Formulae for dislocation generation covering constant rate of stress application and also rapidly applied constant stress were utilized. These theoretical results were compared with measurements of the initial yield in mild steel for both these types of loading, published by J. A. Hendrickson and D. S. Wood. Good agreement was achieved for the temperature and stress rate dependences of the upper yield stress and also for the temperature and applied stress dependences of the yield delay time.

A. Sawaoka, K. Kondo and S. Saito of the Tokyo Institute of Technology presented measurements of the atomic behavior in LiF crystals during shock compression by means of flash x-ray diffraction. They had constructed a flash x-ray generator with the Blumlein circuit improved sensitivity of x-ray detector by using an image intensifier incorporating the microchannel plate electron multiplier. Shock waves of amplitude several hundred kilobars were generated with a double-stage light gas gun. Lattice strain measurements for shock compression along the (100) direction in a single crystal indicated a transformation to a polycrystalline like structure in the shock front which reverted to the original crystalline order after passage of the shock.

D. R. Curran, D. A. Shockey and L. Seaman of the Stanford Research Institute, California, and L. Davison and M. E. Kipp of Sandia Laboratories, New Mexico, presented papers dealing with microscopic rate sensitive processes which lead to spall or fracture damage. In the former paper, the initiation mechanisms: microscopic plastic flow, tensile cleavage cracking, tensile void growth and adiabatic shear banding, were investigated. The forms of the nucleation and growth laws for these mechanisms are given, the characteristic constants being determined from dynamic loading experiments followed by metallographic examination of the specimens to determine the distribution of the flaws. The coupling between the phenomena of wave propagation and flow generation is evaluated through wave propagation computer codes and through the influence of flaw distributions on macroscopic characteristics of the specimens such as elastic stiffness and yield stress. The process is extended to the coalescence of flaws to produce internal fragmentation and loss of tensile strength. The paper by Davison and Kipp investigates the development of spall damage in ductile materials due to stress wave interactions. The growth of small spherical voids initiates the spalling phenomenon. An internal-state-variable theory has been developed to describe the process

and is applied to gain insight into the process of spalling and to discuss the interpretation of experimental observations and to examine the validity of various spall criteria.

MACROSCOPIC ANALYSIS OF MATERIAL CHARACTERISTICS

K. Kawata, S. Hashimoto and K. Kurokawa of the Institute of Space and Aeronautical Sciences of the University of Tokyo discussed the influence of crystal lattice systems on the high strain rate tensile behavior of metals. They showed that FCC metals are more ductile at high rates, whereas BCC metals become more brittle. Forms of dynamic constitutive equations are given for FCC metals, particularly for high strength aluminum alloys which exhibit linear hardening. The contrast between FCC and BCC metals with regard to wave profile for step loading yields a monotonically increasing wave front for the FCC structure and an elastic precursor peak for BCC metals. These wave shapes correspond to monotonically increasing stress-strain curves for the FCC case with an upper yield point for BCC metals.

K. Tanaka, K. Ogawa and T. Nojima of Kyoto University described dynamic compression tests of titanium and its alloys and aluminum and its alloys over a wide temperature range. The split Hopkinson bar apparatus was used. Both impulsive application of the total stress was applied and also stepped stress achieved by means of a stepped striker bar. Strain rate sensitivity sometimes differed for the differential stress tests compared with the total stress step tests indicating hereditary after effects in the material response. Comparision is also made with static compression tests.

T. Nakamura of the Tokyo Institute of Technology discussed the deformation of metals and alloys at high temperatures in the hot working regime. He was particularly concerned with steady state deformation, in which work hardening balances thermal softening effects, and examined ferritic steels, austenitic stainless steel, copper, aluminum and hexagonal zinc. The interdependence of the flow stress, strain rate and temperature investigated provides the fundamental information needed to select practical hot working process variables. Metallographic observations were made to classify the rate controlling mechanisms. The formation of subgrains, dynamic recrystallization and grain refinement were investigated.

J. Klepaczko of the Institute of Fundamental Technical Research, Warsaw, described an investigation concerning frictional influences on measurements of the dynamic compression discs. It is extremely important to be able to incorporate frictional effects in the analyses of such tests if meaningful values of the flow stress are to be deduced.

E. H. Lee and R. L. Mallett of Stanford University, California, considered the dynamic compression of porous ductile metal. Such materials are useful for energy absorption since plastic flow readily occurs associated with deformation of the free surfaces of the cavities or pores. This occurs under pure hydrostatic compressive loading, in contrast to the response of homogeneous metals, since the pores close up and finally collapse with macroscopic volume contraction associated with plastic flow. The dynamics of pore collapse was investigated using the finite element method for elastic-plastic response, and it was shown that the acceleration of material around each cavity as it collapsed led to a system rate effect in the external stress required to continue the deformation which should be added to any basic material rate effect on the stress required for yielding.

T. Mura of Northwestern University, Illinois, discussed displacements, strains, stresses and energies associated with uniformly moving dislocations and inclusions. The stress distribution inside an inclusion was found to be uniform as in the statical case. The relationship between plastic strain and the dislocation density tensor is expressed through the history of dislocation motion. These results provide input to basic understanding of high velocity deformation of solids and fracture mechanics. A new state variable is proposed, the essential dislocation density tensor, which describes dislocation distributions excluding impotent dislocations and stress-free dislocations (Nye's dislocations). This new concept leads to interesting applications in fracture mechanics.

M. Stelly and R. Dormeval of the Commissariat a L'Energie Atomique, France, examined properties of copper subjected to dynamic deformation. A specially built machine using a streak camera to record strains was employed

for tension tests and a split Hopkinson bar for compression tests. Both single crystal and polycrystalline specimens were tested. A stress peak was observed in tension tests followed by stress relaxation. Above a strain rate of 5×10^2 sec.$^{-1}$, a linear increase of stress with strain rate was observed. Varying strain rate histories showed that the behavior of copper at a given strain level depends on loading history. This was assessed on the basis of theories of thermally activated deformation mechanisms. The tension tests at high strain rates led to the generation of plastic waves which could be analysed adequately on the basis of plastic theory.

MEASUREMENT OF MATERIAL CHARACTERISTICS

T. Hayashi and N. Tanimoto described a method for imposing combined tension and torsion in a split Hopkinson bar type apparatus. The striker is pulled and twisted statically and clamped so that, on sudden release of the constraint, combined torsion and tension waves travel through the specimen to the output rod. Proportional loading was produced and dynamic yield surfaces were found to be enlarged compared with the static ones. This was combined with the appearance of rate dependent plasticity laws.

N. Nakagawa, R. Kawai and T. Sasaki of Kobe University presented studies of the propagation of longitudinal waves along rods of viscoelastic material due to impact loading. Solutions for various viscoelastic models were compared with experiment. Comparison of the theory with experiment was particularly significant because the wave generated incorporated a wide range of frequencies.

ANALYSIS OF WAVE PROPAGATION

Wave propagation provides a controlled means of exerting a prescribed stress pulse of short duration on material elements of a body, but dynamic analysis is needed to evaluate the stress-wave profile generated. Very high rates of straining can be achieved particularly when shock-waves are produced. Thus the analysis of wave propagation plays an important role in selecting experimental configurations for measuring material characteristics under high velocity deformation. Concomitantly, such information is needed for the assessement of technological problems involving wave propagation, and dynamical analysis is also needed to understand the response of associated systems. The structure of waves is sensitive to the constitutive relation of the transmitting materials, so that much analytic effort is needed on the study of wave propagation through different types of materials if the characteristics of impact loading problems are to be amenable to adequate prediction. Several papers presented at the Symposium addressed such questions.

In a paper authored by Y. Yamada of the Institute of Industrial Science, University of Tokyo, the development of methods of evaluating stress wave profiles was presented. A generalized Kelvin or Voigt model incorporating instantaneous and delayed elasticity and plastic flow was used since it includes visco-plasticity and Johnston and Gilman's model for metal plasticity. Both finite difference and finite element computational approaches were described, the former involving characteristic integration and the Hugoniot relations across a surface of discontinuity. Applications to wave propagation in viscoelastic materials and in materials exhibiting rate-dependent plasticity were presented.

T. C. T. Ting of the University of Illinois, Chicago, discussed simple waves propagating along the x-direction for a nonlinear elastic medium and examined conditions which might lead, according to standard theory, to material particles inter-penetrating each other. The condition prescribing that such inter-penetration cannot occur can require the inclusion of a shock wave. Such conditions were examined for a commercially pure aluminum.

Wave propagation through materials exhibiting hysteresis in loading-unloading cycles was considered by M. L. Baron and J. P. Wright of Weidlinger Associates, New York. Models involving failure and a plastic cap appropriate for rocks and soils were studied including the effect of dilatancy. Finite difference, finite element and hybrid codes were described, with particular emphasis on high velocity straining due to explosive loading. The influence of the introduction of rate effects into plasticity laws was considered. Whereas rate independent laws predict discontinuities in the stress and velocity profiles, these are suppressed in the case of materials governed by rate-dependent laws. The bearing of all these considerations on the most efficient means of evaluating wave structure was considered.

The propagation of waves through rock containing a series of parallel cracks, across which slip could occur, was considered by L. W. Morland of the University of East Anglia, England. Plane waves with deformation in plane strain were considered, the plane of the wave front being inclined to that of the faults. Wave lengths long compared with the distance between the faults, assumed uniformly distributed, were assumed. A model, including friction between the crack surfaces, reduced to an anisotropic elastic-plastic law with a non-associated flow rule. Wave analysis was carried out for motion initiated by a purely longitudinal pressure pulse.

T. Jimma, T. Masuda and H. Hatakeyama of the Tokyo Institute of Technology analyzed the propagation of elastic-plastic plane waves using the continuum theory of dislocations. Longitudinal and shear step loadings were considered and also a combination of the two. The wave front comprises a plane of dislocations across which stresses and strains are discontinuous, the dislocations being oriented differently for longitudinal and shear waves. A combination of the configurations yields the combined stress solution without the use of characteristic theory.

DYNAMIC FRACTURE CHARACTERISTICS

There is a close coupling between fracture characteristics and speed of deformation as illustrated by the transition from ductile to brittle fracture with increase in rate of straining or decrease of temperature. K. B. Broberg of the Lund Institute of Technology, Sweden, discussed several aspects indicating a growth of the region of plastic separation in a running ductile crack as the speed increases, and this led to an increase in the energy dissipated. Measurements of the crack propagation velocity and the effects on fracture caused by its variation were described by A. Kobayashi and N. Ohtani of the Institute of Space and Aeronautical Sciences of the University of Tokyo. Experiments with the plastics lucite (plexiglass) and polycarbonate (Lexan) were reported on by W. Goldsmith of the University of California at Berkeley and F. Katsamanis of the Technical University of Athens, Greece. Thin rectangular plates, artifically "cracked" with saw cuts, were impacted by pneumatically propelled steel spheres, and high speed photographs determined the crack growth and the stress-intensity factor. Critical stress levels for crack propagation or arrest through bifurcation were determined, and the dynamic characteristics were compared with corresponding static values. W. Johnson and A. G. Mamalis of Cambridge University, England, discussed fracture and void development in hemi-spherical ended rods of Perspex and plaster of Paris due to end explosive loading. Geometrical optics of the stress-wave fronts provided an explanation of the fracture patterns obtained.

The analysis of the stress and deformation in a cylinder projected parallel to its axis against a rigid wall was presented by H. Fukuoka and H. Toda of Osaka University. It was based on elastic-viscoplastic material response. They solved the axisymmetric dynamic problem with moving boundaries using the finite difference method by means of the theory of bicharacteristics. They compared the solution with strain measurements on a low carbon mild steel cylinder obtained by using a high speed camera having a capacity of 200,000 frames per second. The solution based on cylindrical coordinates gave better agreement with experiment than an earlier evaluation based on longitudinal wave analysis.

TECHNOLOGICAL APPLICATIONS

A number of papers presented at the Symposium dealt with technological applications which involved analysis and material characteristics appropriate for high speed deformation. Resistance of structures to penetration by projectiles is such an important area of concern. R. Kinslow of the Tennessee Technological University discussed spall formation, associated with fracture caused by tensile stresses which result from the reflection of a pressure pulse at the rear surface of the target plate. Simple criteria for spalling based on the analyses of plane elastic waves were presented. D. C. Drucker of the University of Illinois at Urbana-Champaign discussed impact of small projectiles and drops of water striking with a speed range from a fraction of the speed of sound in the target material to many times that speed. An approximate expression for crater volumes was determined taking into account the kinetic energy transfer ratio. Craters in brittle and friable material were also discussed. A spall criterion for high velocity impact on plates was derived which was insensitive to the fine details of separation on the microscale.

Several papers reported on experimental measurements of penetration by projectiles. T. Shioya of the Department of Aeronautics and K. Kawata of the Institute of Space and Aeronautical Sciences, both of the University

of Tokyo, measured the penetration of steel balls into blocks of epoxy resin. Impact velocities up to 2400 m./sec. were reached in the high speed range, and tests were carried out down to 0.1 mm./min. in an Instron type testing machine. In the high speed range the epoxy resin tended to close in behind the projectile leaving little trace, but above 1300 m./sec. cracks spread into the target material from the penetrating projectile. At high speeds the total penetration was proportional to velocity, but this became a logarithmic relation at lower speeds. The temperature dependence of the process was measured, and an activation energy calculated which correlated with the breaking of bonds in the polymer chains.

L. E. Malvern, R. L. Sierakowshi and C. A. Ross of the University of Florida and N. Cristescu of that University and of the University of Bucharest, Romania, discussed the penetration of small rigid projectiles into laminated fiber-reinforced composites. In particular they studied experimentally the delamination associated with partial penetration. They found a linear relationship between impactor kinetic energy and total delamination area above a threshold energy. They also examined the delamination process for special geometries such as blunt ended cylinders.

The ricochet of spherical and ogival projectiles from water, sand and clay surfaces was described by W. Johnson and G. H. Daneshi of Cambridge University. The information was obtained by photographing the projectiles at specific time intervals during the process, and using the distance-time curves so obtained to calculate the forces acting. Exit speed, angle and spin were measured for various angles and speed of incidence. Crater development was discussed.

High velocity impact of two metal plates was investigated by K. Kiyota of Yatsushiro College of Technology and M. Fujita of Kumamoto University with the objectives of obtaining impulsive welding. The plates were projected by means of explosively generated shock waves in water, to collide obliquely at high velocity. A metal jet is formed between the contact surfaces of the plates cleaning the surfaces so that they bond metallurgically. An apparatus was designed, called a conical shock-wave generator, which produced good bonds over almost the entire area of contact.

A number of papers were concerned with the dynamic response, of structures and structural elements. S. Kawashima of Kyushu University, Fukuoka, analysed and carried out experiments on long aluminum beams subjected to high velocity transverse impact. Plastic bending wave theory using a rate dependent plasticity law gave adequate agreement with experiments. Shear effects were significant, but rotary inertia not so. M. S. El Naschie of the University of Riyadh, Saudi Arabia, and University College, London, discussed the instability of convex shells. The work emphasized the need for a simple concept for shell instabilities. An investigation of shock and vibration characteristics of solid propellant rockets was discussed by D. Mori and J. Onoda of the Institute of Space and Aeronautical Sciences of the University of Tokyo. Measured results of flexural vibration of the structure were compared with analytical predictions. The effect of the solid propellant grains was analyzed by the finite element method and checked with measurements on a small test model.

A single paper was presented at the Symposium concerned with impact on a biological structure: the human head, with authors S. Kobayashi and H. Tomita of the Aeronautics Department of the University of Tokyo and T. Kobayashi of the Mitsubishi Heavy Industry Company. The head was modeled as an axisymmetric shell containing a soft elastic continuum having a Poisson's ratio close to 0.5. High membrane and bending stress occurred at the impact point but high negative pressures occurred in the "brain" material adjacent to the "counter pole" diametrically opposite to the point of impact.

At the end of the Symposium, Professor Kowata offered a brief report on the Research Committee of Shock-Resistant Structures, which had been formed in 1976 under the sponsorship of the Japan Automobile Research Institute to study the impact properties of the main structural components of the automobile and the structural characteristics of the whole system. The objective was to find feasible shock-resistant configurations. The Committee consists of eight university members and four from research institutes. Various studies of the crash-worthiness of structures are underway.

CONFERENCE REPORT ON THE INTERNATIONAL UNION OF THEORETICAL AND APPLIED MECHANICS (IUTAM) SYMPOSIUM: HIGH VELOCITY DEFORMATION OF SOLIDS – E. H. LEE

COMMENTS

As discussed in the Introduction to this report, deformation of solids at high rates of strain poses challenging problems because the influence of factors not considered in the classical theories of the deformation of solids becomes significant. For ductile metals these factors include strain rate influence on yield and deformation, and for brittle materials the generation of microscopic flaws and cracks which determine the macroscopic behavior. As pointed out by Professor R. J. Clifton of Brown University at an National Science Foundation Workshop on Non-linear Waves in Solids held at the University of Illinois at Chicago Circle in March 1977, the most challenging obstacle to the development of a capability to be able to evaluate the behavior of systems governed by this phenomenon is the formulation of constitutive relations which accurately express the physical response of solids to general loading. The development of techniques of measurement during short time loading and of computational means of solving the equations of motion have far outstripped our ability to formulate adequate mathematical representations of the material response. It is therefore appropriate that contributions to this Symposium were in the main devoted to the task of understanding and hence forming a basis for the mathematical representation of material response. This included a combination of microscopic and macroscopic studies in material science and in continuum mechanics based on a foundation of experimental findings. The assessment of the current state of knowledge which these contributions embody provided a useful bench mark of future research.

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EIGHTH STOCHASTIC PROCESS CONFERENCE

Bruce J. McDonald

The Eighth Conference on Stochastic Processes and their Applications was held from 6 through 10 July 1978 on the campus of the Australian National University in Canberra, Australia. It is one of series which has been held under the auspices of the Bernouilli Society for Mathematical Statistics and Probability (The Bernouilli Society is a component of the International Statistical Institute). This Conference was sponsored by the Australian Academy of Science and cosponsors included the Australian Mathematical Society, The Australian Society for Operations Research, The Statistical Society of Australia and The CSIRO (Commonwealth Scientific and Industrial Research Organization) Division of Mathematics and Statistics. Assistance was provided by IBM (Australia). The attendees numbered about one hundred and forty including some twenty-five persons from distant countries such as the United States, United Kingdom, Japan, Union of Soviet Socialist Republics, and India. This compares well with earlier conferences in the series. The largest predecessor was the 1973 Conference in Sheffield, United Kingdom, where two hundred participants were recorded and the smallest was the 1976 Conference in Israel where one hundred and four registered. The good turn out for this conference stems in large part from the vigorous and capable group of Australians who organized the Conference. Headed up by Dr. C. C. "Chris" Heyde of CSIRO's Division of Mathematics and Statistics (DMS), the group missed no opportunities to draw the Australian mathematical sciences community into the meeting. In addition to organizing an excellent Program, they arranged two follow-on meetings on closely related themes. One was a four day meeting of the Statistical Society of Australia with an extensive technical program which emphasized applications of mathematical sciences, the other a four-day conference of the technical staff of CSIRO-DMS which comprehensively reviewed current DMS activities at its headquarters in Canberra and at its field offices located in eight cities distributed along the Australian coast. These latter two meetings provided a healthy balance and significantly enhanced the Stochastic Processes Conference which, by its intrinsic nature, is somewhat theoretical. The ensemble of meetings provided the Australian attendees with an opportunity to do some domestic business while getting an excellent, current summary of research activity in stochastic processes, while attendees from outside Australia had an excellent chance to conveniently meet mathematical scientists from all over Australia.

In the twenty-two technical sessions, fifteen invited and fifty contributed papers were presented. They covered a wide range of topics and varied in character from extremely theoretical to somewhat applied.

Professor M. R. Leadbetter of the University of North Carolina presented a paper on dependent extreme value theory. He included a summary of the recent work of several authors who have jointly succeeded, to a rather complete and satisfying degree, in extending the classical (distributional) extreme value theory from the independent, indentically distributed random variable context to include stationary sequences. He also included the considerably less complete extension of the theory which is currently seeking to handle the extremes of continuous parameter processes. Also covered were connections with the theory of "level crossings" which yield useful criteria concerning domains of attraction.

R. B. Davies of the Applied Mathematics Division of the New Zealand Department of Scientific and Industrial Research in Wellington, N.Z., presented a paper on the quite general problem of statistical inference in nonergodic time series. Davies considered the finite dimensional parameter space situation and introduced an "asymptotic model" for the process. He then extended some results of Le Cam to obtain conditions wherein a given procedure which is optimal for the asymptotic model can be used to derive a corresponding procedure which is asymptotically optimal for the actual model. His results have relevance to sequential estimation and testing.

J. R. Sutton of the School of Mathematical Sciences of the New South Wales Institute of Technology in Sydney has used stochastic process methodology to develop a stochastic model for acoustic wave propagation

through the ocean. He has concentrated on modelling how an acoustic field which propagates through the ocean interacts with the temperature microstructure of the ocean. He seeks to relate the directional energy spectrum of the resultant scattered acoustic field, to the statistics of the micro-structure. He forsees using such methods to (1) develop estimates of the resolution capabilities of aperture types of acoustic sensors and (2) estimate ocean dynamic parameters from ocean temperature microstructure. His considerations include the infinite ocean case and also the waveguide ocean case.

The breadth and diversity of the presentations is further exemplified by the following list of abbreviated titles from some of the other papers given: renewal processes, upcrossings, filtering theory, spatial processes, queueing and storage systems in parallel, multivariate point processes in teletraffic systems, control theory, time series and random fluid flow in the plane.

In summary, the Conference reflected a great deal of strong theoretical progress in the stochastic process subject matter and fully reinforced this writer's previous conviction that stochastic process methodology has very strong potential for contributing to the eventual solution of many of the chronically difficult, practical problems of current science and technology.